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DIVISION OF WATERSHED MANAGEMENT RESEARCH

Semiannual Report

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

October 1958 - March 1959

USE OF THIS REPORT

This report is not a publication and should not be referred to in literature citations. The report is prepared by the station staffs of the Division of Watershed Management Research, specifically as a means of exchanging information on program activities, research methods and techniques, preliminary research results, and research concepts. The contents of the report should not be used by persons who are not in a position to analyze and interpret the preliminary results and tentative findings of the studies reported herein. If further information is desired, it should be obtained directly from the station involved. Any citations should refer to communications from the station, with the station's approval.

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SEMIANNUAL REPORT
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Washington Office

The big change in the Washington Office was the retirement of Bernie Frank. Bernie had been a part of the Division in Washington almost from the beginning so his departure has left one of those voids that one subconsciously feels -- you know, the little man that isn't there. He has taken a job with FAO to assist the Government of India develop a program of watershed management research. Bernie's address is Forestry Officer, FAO, c/o Forest Research Institute, Dehra Dun, U. P. India, if any of you would like to write him.

Plastic Film for Weir Ponds

We have given Howard Lull an assist in obtaining information on the use of plastic film to line weir ponds by referring him to Dr. C. E. Staff, Union Carbide Plastics Company, 30 East 42nd Street, New York 17, New York. Howard, in his modesty, has sent the following information from Dr. Staff, for inclusion in the W.O. section of the report rather than under the NE Station section.

> Vinyl and polyethylene are practically the only two films which are satisfactory for this operation since we need an elastic material which will conform to the surface. We do not count upon the strength of the plastic, but rather on its impermeability, allowing for support from the base material. With a rigid material like Styrene, Mylar or other films, some of which raw material is also supplied by Union Carbide Plastics, we would be depending upon the tensile strength of the film and this would require a heavier gauge, than is necessary for impermeability.
>
> It is rather difficult to decide which plastic to use for this application and the advantages and disadvantages to each. My preference at present is for a vinyl film, particularly if it is to be used as a buried membrane, similar to the technique promoted for asphaltic liners by the Bureau of Reclamation. In an exposed membrane polyethylene of satisfactory opacity is probably preferable. The black vinyl film we are now producing for this application we anticipate will have an exposed life in the northern latitudes of 3 to 5 years, and buried life of 10 to 15 years. The carbon black is incorporated in the film and not as a coating as mentioned in the report. In order to decrease the cost of these films for this application, Union Carbide Plastics Company began fabricating 54 inch wide strips of film into widths up to 61 ft., and length as required for this application. The strips can be readily joined together by the aid of the adhesive supplied, for covering any size area. We are currently selling this material at 40¢ per sq. yd. in the .008" thickness, but anticipate that it will be sold eventually through dealers at a somewhat higher price.

(Over)

In contrast to vinyl film similar to the attached sample, which is quite elastic and tough and puncture resistant, polyethylene film is considerably stiffer, more easily damaged, is difficult to field repair or join together, but is cheaper, and has greater outdoor exposure durability. Most polyethylene is heat sealed together but the seals have been quite poor frequently, although satisfactory techniques for this are available if they could only be introduced into the trade. Although I again would prefer an .008" film, .008" films are not generally available but .006" films are available in widths up to 32 ft., at a retail price of 3 or 4¢ per sq. ft. Some of the films on the market are not as opaque as I believe they should be for maximum durability outdoors, and we are trying to get this situation improved for a longer term application.

We would be interested in supplying you with materials at the current price of 40¢ per sq. yd. in the widths available. It is not difficult to obtain a watertight seal with the adhesive supplied and the film itself is practically hole free, the specifications being not over one hole per 10 sq. yds. of 1/32 inch or greater in diameter. If possible the film should be protected from mechanical damage by animals to extend its life. The film however has been walked upon in canal installations by cattle, deer, etc., without puncturing, but it is always risky.

Watershed Research Meeting

Herb Storey met with the watershed research division chiefs and a few project leaders at San Dimas for a week in January to look ahead at the nationwide research program, problems of coordination of regional programs, personnel recruitment and training needs, and specialized laboratory program and facility needs for Watershed Management Research. The meeting was very worthwhile and produced a lot of good ideas.

Public Law 480 Program

A new activity for the W.O. has been instigated by the inclusion of research in the provisions of Public Law 480. P. L. 480 provides for the disposal of surplus agricultural commodities to needy foreign countries and authorizes the acceptance of foreign currencies in payment. The law further provides certain avenues for the use of these foreign currencies and one of these is for the conduct of basic research in the countries whose currencies are held and where scientists and facilities are available for doing research. The research must be of benefit to the United States and such that it can be better done in the foreign country than in the U.S.A. During the winter, several teams were sent to Europe, the Far East, and Latin America to introduce this program and to survey for interest, facilities and personnel. Some proposals are now coming in for consideration by the Department and the functional division concerned. So far we have had proposals from Poland, France, and Indonesia. We are also having translations done under this program but we suspect these may be slow in coming.

SEMIANNUAL REPORT

Division of Watershed Management Research
California Forest and Range Experiment Station

October 1958 through March 1959

GENERAL

After one-third of a century the California Station name will be changed on April 15, 1959 to Pacific Southwest Forest and Range Experiment Station. The new name will reflect our broadened responsibilities in the new State of Hawaii and conform to the naming pattern of other stations.

It has been a dry winter in California. Rainfall at Tanbark Flat for the period October 1, 1958 to April 1, 1959 was 12.45 inches. This is 52 percent of the 30-year normal of 23.9 inches for the same period. To date, only February has exceeded or equalled the 30-year average. March was the driest on record--no rain at all.

In the high country we couldn't have had a better snow year, research-wise, if we'd wished for it. The snow pack at Central Sierra Snow Laboratory was only half normal at the end of March--the opposite extreme from last year's nearly double normal record. This is good for research, but rough on the State's water supply.

The Colman Watershed Fellowship Fund now amounts to approximately $32,000. Income from the fund is being impounded by the University of California toward award of the first Edward A. Colman Memorial Fellowship.

PERSONNEL

Jane Lackey, a former member of the WAVES, joined the clerical and typing staff at Glendora in October.

Dave Miller joined our Berkeley Snow staff on January 1. He brings wide research experience in snow, climatology, and heat budget analysis. Dave was formerly in charge of environmental studies for the Quartermaster Corps, and before that worked in the old Snow Investigations of the Corps of Engineers.

Tom Pagenhart has returned to the University of California to complete his Ph.D. work in the Geography Department.

Arnold Court is temporarily spending most of his time on evaluation of cloud-seeding and high level winds for Civil Defense.

Ken Knoerr came down out of the hills and is now working out of Berkeley. Johnnie Andre' took Ken's place at the Central Sierra Snow Laboratory.

PUBLICATIONS

Manuscripts Published

Anderson, H. W.
Progress in snow management research in California. 26th Ann. Proc., Western Snow Conf. pp. 12-21, 1958. (Abstracted in Semiannual Report for Apr.-Sept. 1958.)

Anderson, H. W., Rice, R. M., and West, A. J.
Snow in forest openings and forest stands. Proc. Soc. Amer. Foresters 1958, pp. 46-50.

Snow accumulation and melt in 1958 at 57 snow courses were analyzed and the effects of forest openings and margins and of forest density were interpreted. The analyses suggest that L-shaped openings might be best on east and west slopes while strips 1 to 2 tree-heights wide might be best on north and south slopes.

Anderson, H. W., Rice, R. M., and West, A. J.
Forest shade related to snow accumulation. 26th Ann. Proc., Western Snow Conf. pp. 21-31, 1958. (Abstracted in Semiannual Report for Apr.-Sept. 1958.)

Court, Arnold
Selection of "best" snow course points. 26th Ann. Proc., Western Snow Conf., pp. 1-12, 1958. (Abstracted in Semiannual Report for Apr.-Sept. 1958.)

Hamilton, E. L. and Reimann, L. F.
Simplified methods of sampling rainfall on the San Dimas Experimental Forest. California Forest and Range Experiment Station Tech. Paper 26, 8 pp., October 1958.

By refining rainfall measurement techniques and sampling methods, a 21 gage network was made more useful than a former network of 300 gages.

Hopkins, Walt
Cooperative financing of water management projects in California. Proceedings of Second Annual Meeting, Arizona Watershed Program, pp. 63-66, September 1958.

Hopkins, Walt, Sinclair, J. D., and Rowe, P. B.
From forest influences to applied watershed management in southern California. Proc. Soc. Amer. Foresters, 1958, pp. 36-38. (Abstracted in Semiannual Report for Apr.-Sept. 1958.)

A brief review of past research accomplishments at San Dimas and discussion of current water yield studies.

Merriam, R. A.
Nuclear probe compared with other soil moisture measurement methods. California Forest and Range Experiment Station Research Note 146, 5 pp., January 1959.

Gravimetric, Colman unit, and nuclear probe soil moisture measurements provide similar values in San Dimas lysimeters.

Rice, R. M.
Snow management research in High Sierra range. Jour. Range Mgmt. 12:13-16, 1959. (Abstracted in Semiannual Report for Apr.-Sept. 1958.)

Rowe, P. B.
Tests of applied watershed management to increase water yield--San Dimas Experimental Forest. Proceedings of Second Annual Meeting, Arizona Watershed Program, pp. 59-62, illus., September 1958.

Discussion of San Dimas soil moisture-brush conversion plot results and applied water yield studies in Big Dalton Canyon.

Manuscripts Accepted for Publication

Anderson, H. W., and Hobba, R. L.
Forest effects on floods in northwestern United States. Submitted for presentation at Symposium on Forests and Water, Hannover-Munden, Germany, Sept. 1959.

Patric, J. H.
Higher water yields from southern California mountains. Jour. of Amer. Water Works Assn.

Sinclair, J. D. and Patric, J. H.
The San Dimas disturbed soil lysimeters. Submitted for presentation at Symposium on Forests and Water, Hannover-Munden, Germany, Sept. 1959.

West, A. J., and Knoerr, K. R.
Winter and summer water losses in the High Sierra. Jour. Amer. Water Works Assn., Apr. 1959.

File Reports

Court, Arnold
Radiation computations. CF&RES file report, Oct. 31, 1958. 3 pp. proc.

Court, Arnold
Dewcel-thermocouple formulas. CF&RES file report, Feb. 6, 1959. 4 pp.

Knoerr, K. R.
Nuclear-Chicago P-19 soil moisture probe -- comments on first year's use for soil moisture measurements. CF&RES file report, Mar. 5, 1959, 6 pp.

Miller, D. H.
Readings for geographers in the literature of hydrology. Jan. 20, 1959. 21 pp. proc.

CURRENT RESEARCH

San Dimas Experimental Forest

Watershed Management Tests to Increase Water Yield

Logging and clearing of riparian vegetation "recommenced" in Monroe Canyon on January 18, after its interruption by an exceptionally late fire season. Brush clearing and slash removal is being handled by labor crews contributed by the Los Angeles County Forester and Fire Wardens office. So far, five more acres of canyon bottom have been added to the 15 completed last year.

Streamflow persisted in Monroe Canyon throughout the dry season while other streams in the Big Dalton drainage failed late in the summer. Where adequately treated with 2,4-D and 2,4,5-T, tree stumps have died or sprouted with markedly less vigor than have untreated stumps. Grass is not rapidly occupying the cutover area, a disappointment attributable to the season's low rainfall.

Last spring's helicopter phytocide spray job on 41 acres of brush in Bell Small Watershed No. 2 gave a good leaf kill. At least 75 percent of the foliage died, but five months later most species started to regrow from branches over one-half inch in diameter. This spring we will respray when regrowth nears its peak. This time it should be possible to apply the spray for appreciably less than the $30.50 cost per acre of last year. So far, defoliating the mountain-side brush has had no obvious influence on streamflow from this watershed.

The San Dimas Lysimeters

Coulter pines in a large, conventional lysimeter were compared with those growing in an unconfined block of similar lysimeter soil. The growth of these trees provides a ready means of comparing plant environments identical expect for walls and the bottom of lysimeter containing the soil. Trees outside the lysimeter are markedly more vigorous than those with root systems contained in the tanks. The following tabulation specifies differences that are apparent to even the casual on-site observer.

Criterion	Unconfined Soil	Conventional Lysimeter	U/C Ratio
Total height	16.9 feet	10.9 feet	1.55
Diameter 1 inch over soil	3.5 inches	2.1 inches	1.67
Height increase (Average of 5 dry years)	1.3 feet	0.9 feet	1.44
Height increase (1 wet year)	1.9 feet	1.3 feet	1.46
Stem volume	.74 cubic ft.	.17 cubic ft.	4.45

Soil Moisture Sampling

The soil moisture sampling program with the neutron probe on the Bell small watersheds is just getting underway. Access tubes were installed with the aid of a "Mighty Midget" drill, made by Houston Tool Company of Santa Susanna, California. It has been very successful. Most of our holes are about 20 feet deep. One is 37 feet. We recently had our probe (Nuclear-Chicago) modified with the new non-temperature sensitive pre-amp circuit. We do not know exactly what the effect on calibration is, but count rate has increased about 10 percent at the few soil moisture contents we have checked.

Grass Interception Study

The new study of water loss through interception of rainfall by grass is off to a slow start, owing to lack of rainfall. Several sampling sites were prepared and seeded with soft chess but there has been very little growth to date. Irrigation of small areas when rainfall failed invited an insect epidemic. Nevertheless, irrigating has finally provided a good grass cover and we plan to use "artificial rain" if necessary to develop interception measurement techniques.

Snow Studies

Snow Accumulation and Melt

First analyses of 1958 snow course data at Central Sierra Snow Laboratory suggest that wind and cold air drainage are probably dominant processes in snow accumulation in forest openings. When snow accumulations on north south, east and west slopes were compared, the maximum accumulation was always on the downhill side of the openings.

Within forest stands adjacent to openings, wind and shade effects were dominant--back eddies from the southwest winds and shade from the trees. Maximum snow was generally found in the southwest forest margin. The snow was apparently "stolen" from the opposite northeast margin. The largest differences were on south and west slopes--11 inches of water on south slopes, 6 inches on west slopes. Differences on north and east slopes and on the level were smaller.

Spring snowmelt was always least in the south parts of forest margins. Shade was the dominant influence. In the forest margins adjacent to openings, snowmelt was highly variable, defying simple explanation. The interplay of direct solar radiation, cold air drainage, and condensation require more measurement before we can explain the net variations in melt in the forest adjacent to openings. Data and fuller interpretations from these studies are given in the 1958 Proc. of Soc, Amer. Foresters, pp. 46-50.

Tools and Techniques

Dewcel-Thermocouple Formulas

Dewpoint is measured in the Foxboro "Dewcel" as a function of the temperature to which a standard solution of lithium chloride must be heated until its vapor pressure equals that of the air. When the potential of an iron-constantan thermocouple is used to measure the temperature, special formulas are needed. Arnold Court has worked out formulas which facilitate calculations of dewpoints by electrical computers. A generalized formula gives dewpoints within accuracy of 0.4°C:

$$u = 13.32y - 23.70$$

("u" is the dewpoint (°C), and "y" is the millivolt potential from the thermocouple.)

In another report Court gives formulas for computing radiation on electronic computors from Beckman and Whitely radiometers. Court's file reports, as well of those of Miller and Knoerr will be furnished on request.

Photocanopymeter

Since the last Semiannual Report, we have accumulated considerable field and office experience in using photocanopymeter pictures. From the ground looking skyward, we have taken pictures of the forest canopy at about 1,500 snow and soil moisture sampling points.

Five hundred of these have been analyzed. We have designed grids and templates to measure the hemispherical cover and the shade for various solar paths throughout the year. Upon checking our work we found that after a little practice, shade and hemispherical cover measurements (grid overlay estimates) were reproducible by different operators within limits of $\pm$ 3 percent.

We are pretty much sold on this technique for recording cover. However, if you want to make a camera, check with us before proceeding. We have discovered several "bugs" and some "gimmicks" that might help you.

MEETINGS

October 1.--Bob Merriam spoke at the annual meeting of the California Association of Soil Conservation Districts, Region 7, in Beaumont. His talk outlined the work in watershed management currently under way at San Dimas.

October 9.--The Snow staff had a conference with the State Department of Water Resources in Sacramento. Snow research progress was outlined and plans were discussed.

October 9.--Geoffrey Coleman, formerly with San Dimas Experimental Forest, now Assistant Ranger on the Angeles National Forest, discussed "Summer slides and winter scour - dry-wet erosion in southern California mountains," based on a paper by Henry Anderson, Coleman, and Paul Zinke.at a Section meeting of the American Society of Agricultural Engineers in Riverside, October 10, the group made a field tour of the San Dimas Experimental Forest. Included was a stop at Tanbark Flat for a discussion of Watershed Management and Fuel-Break research.

October 23.--Walt Hopkins presented the Watershed Management Research program at San Francisco Chapter meeting of the Society American Foresters.

October 31.--Jim Patric and Al West presented papers at the American Water Works Association meeting in Los Angeles. In "Higher water yields from southern California mountains" Patric reviewed some of the watershed research carried on at the San Dimas Experimental Forest in cooperation with various State agencies. In "Winter and summer water losses in the High Sierra Nevada," by West and Ken Knoerr, West gave the results of these studies at the Central Sierra Snow Laboratory.

January 5.--The Snow staff and the State Department of Water Resources held a one day discussion in Sacramento on their studies and ours of water losses.

January 7.--Walt Hopkins addressed the Lions Club of Auburn, California, on "Snow management research in California."

January 7-8.--Hopkins and Anderson presented research program and results to the Regional Office staff.

January 12.--Johnnie Andre' talked to the Kiwanis Club in Walnut Creek on "How to improve California's water."

January 16.--The Snow staff attended the California Snow Survey Conference in Porterville.

January 18-23.--Walt Hopkins, Henry Anderson, and Perc Rowe represented the Station in the service-wide Watershed Management Research Conference held at Tanbark.

January 20.--Jim Patric spoke on watershed problems to the Alhambra Rod and Gun Club.

February 6.--Ken Knoerr presented a paper entitled "Soil moisture measurements with nuclear probe at Central Sierra Snow Laboratory," at the Pacific Southwest meeting of American Geophysical Union at Stanford University.

February 9-10.--Hopkins, Bentley, Edmunson and Rickel met with Angeles personnel for a 2-day Los Angeles River Watershed cover improvement conference.

February 19-20.--Hopkins, Anderson, Rice and Bentley presented papers at the Station's annual public research review at Fresno.

March 2.--Al West spoke to the Rotary Club of Truckee on "Research progress at the Central Sierra Snow Laboratory."

March 6.--Al West and Johnnie Andre' spoke to the Tahoe Forest Forum, Society of American Foresters, at Nevada City, describing research conducted at the Central Sierra Snow Laboratory.

March 31-April 1.--Tove Arvola and Lee Burcham of the California Division of Forestry spent 2 days inspecting cooperative research.

COOPERATION

Richard A. Lavine, U. S. Attorney's office, Los Angeles, Harry D. Steward, attorney representing plaintiffs, and J. A. Hanson of the Vista-Escondido Water Districts met with Rowe on October 17 to discuss water problems and damages to the Vista-Escondido water supply resulting from the Pine Mountain fire started by a Navy plane in September 1956. Rowe prepared a memo report for those involved covering this meeting and subsequent discussions of the damage case.

Donald J. Finlayson, Senior Hydraulic Engineer, and G. I. Matson, Hydraulic Engineer of the State Water Rights Board, met with Reimann and Rowe to discuss and examine hydrologic information concerning disposition of rainfall in watersheds of the San Fernando Basin pertinent to a water rights dispute between the City of Los Angeles and other cities in the drainage.

The California Farm Bureau Federation Wild Game and Public Land Use Committee met at Tanbark Flat on the San Dimas Experimental Forest. A field trip by the Committee included the Watershed Management project on the San Dimas Experimental Forest and nearby Fuel-Break and Forest Fire Research studies.

A. L. Sharp, Supervising Hydrologist, WTRB, Agricultural Research Service, Lincoln, Nebraska, called at the Glendora office to discuss with Rowe some of the problems encountered in the cooperative water yield study Sharp is heading up.

The Los Angeles County Flood Control District assisted San Dimas personnel in the establishment of channel cross-sections and profiles for determining the effects of the Monroe Canyon treatment on erosion. The California Department of Water Resources has collected samples of the streamflow from the treated and control watershed for chemical analysis. The Department of Irrigation and Soil Science at the University of California, Los Angeles, has been assisting in the installation of access tubes for our neutron probe soil moisture sampling through the loan of a portable drill and personnel to help operate it. The California Division of Forestry continued the training program for its junior personnel with the assignment of Tom Neilson to San Dimas for 2 weeks in October. The Los Angeles County Forester and Fire Warden's Office is contributing the efforts of a juvenile labor crew to help in clearing riparian vegetation from Monroe Canyon.

William Berry, Carl Meyer, Charles McCullough and others from the State of California, Department of Water Resources made 2-day visits to both the Snow Lab and San Dimas Experimental Forest.

The Department of Water Resources is now making arrangements to employ a statistical clerk to tabulate streamflow data under Reimann's supervision and to provide Bendix computer services all aimed at speeding publication of streamflow records.

Henry Anderson outlined analytic procedures in evaluation of fire effects on discharges to Mr. Markowitz of the Soil Conservation Service. Anderson also outlined analytic procedures for estimating natural water losses to Mr. Enger of the Pacific Gas and Electric Company.

The Snow group at Berkeley met with a research team from the Giannini Foundation, University of California, to discuss cooperative research in the economics of water resource management. Informal arrangements were made toward initiating such research.

In preparation for review and publication of streamflow records by the U. S. Geological Survey, Clark Gleason escorted W. W. Dean and S.E. Rantz to the Teakettle and Onion Creek experimental forests. Suggestions were made to standardize the streamgaging procedures in line with those used by the Survey.

VISITORS

The San Dimas Experimental Forest was visited by 149 persons during the 6-month period. Included were 95 college students and 5 foreign visitors representing Kenya, Pakistan, Turkey, and Yugoslavia.

The Central Sierra Snow Laboratory was visited by a number of groups and individuals, as follows:

Congressman Harold Johnson, Member of Congress, Roseville, California

Members of the California State Board of Forestry, Wendell Robie, Chairman

Members of the California State Water Commission, Department of Water Resources

Robert Durbrow, Executive of the Irrigation Districts Association, California

Martin Huberty, Director, Water Resources Center, University of California at Los Angeles

Francis Blanchard, Manager, Water Resources and Planning Division, East Bay Municipal Utility District, Oakland.

In closing, we consider it necessary to point out that although we were host to Mr. Olindo Romulus Angelillo at both the Snow Lab and San Dimas in recent weeks we have not lost faith in our fellow man.

SEMIANNUAL REPORT

DIVISION OF WATERSHED MANAGEMENT RESEARCH

CENTRAL STATES FOREST EXPERIMENT STATION

October 1, 1958 - March 31, 1959

GENERAL

Watershed Management Research at Central States is now being concentrated in the state of Ohio. Much general information has been assembled in an analysis of the water problems of the area. Some of this information was presented and discussed in an overall program conference of the Athens Research Center. This two day conference was held in Columbus and was attended by the technical staff from the Athens Center, Center Leaders from Bedford and Berea, Director, and Division Chiefs, and others of the Columbus technical staff. From this analysis and discussion, studies of subsoil water management and of the influence of forest stand density upon the availability of water were suggested as appropriate for the present research program.

SUBSOIL WATER MANAGEMENT

R. Z. Whipkey

Introduction

Water problems of the Central States in the last few years have ranged from severe drought to extreme flooding. The most recent crisis--the Ohio floods of January and February 1959. It is ironic that while good useable supplies are inadequate in some parts of Ohio, the flood runoff in the January storms would have supplied the state's population with water for a whole year. During the February floods, one town in central Ohio, population 45,000, went on temporary water rationing when the municipal water supply system failed.

These floods were extreme examples of undesirable, high yields in a short period of time. And, the manner in which the flood waters were delivered points up the seriousness of the problem even on forested lands. For example, on open lands almost all the rain that fell ran off the surface of the land because the soil was frozen. But, on two well stocked, undisturbed, hardwood forest watersheds having no concrete frost, delayed high rates of runoff came from subsurface stormflow.

The Central States Forest Experiment Station now proposes to investigate subsurface runoff because its processes must be understood before subsoil treatments can be tested, evaluated, and recommended.

The Problem

Watershed management research in Ohio has shown that overland flow and erosion are negligible where the timber cover is undisturbed. Soils on one Ohio forested watershed, undisturbed for ten years, were improved to the extent that transmission rates within the root zone and infiltration capacities were twice those of cultivated soils in adjacent fields.

Yet, surface water engineers point out that channel stages downstream from this area are still as high from the yearly maximum storms as they were when destructive cultivation and grazing were occurring on the upstream slopes. Storm runoff is now derived almost entirely from lateral water movement through the soil profile. But, overland flow and sedimentation are no longer occurring from the restored areas because the soils have become more permeable.

Ohio's forests are found mainly on shallow-profile slopes where cultivation has either been abandoned or never attempted. The limited water storage capacity of these shallow, forest soils is closely related to the behavior and quantity of subsurface flow that comes from the forested areas. The relation can be described by the familiar storage equation--"When storage capacity of a reservoir is exceeded by the quantity of inflow, outflow will occur at almost the same rate as inflow." Though the timing of this subsurface flow may be delayed enough to prevent the "small-area" flood on localized areas, significant quantities of water may still be contributed to the major downstream channels during the flood period.

Though the forest cover has brought about good receptive conditions for water entry and movement within the soil, this water is still "lost" during the storm period. This "loss" implies that infiltrated water is not going into storage for groundwater flow in dry spells, is not available as soil moisture for plant use, but drains out rapidly and may contribute to flood stages in the major rivers.

So little is known of subsurface stormflow and the conditions affecting rates and quantities that remedial treatment, either mechanical or vegetative, cannot be logically attempted or recommended at this time.

Objectives

The primary objective will be to study the hydraulics of subsurface stormflow from Ohio forest soils so that a general equation of flow can be formulated, and coefficients for specific watershed and climatic factors derived. Of equal importance is the development of treatments for "management of subsoil water," but this must follow the studies of processes.

Past Studies on Subsurface Stormflow

Reisbol in discussing subsurface runoff in the northern Appalachian region pointed out that in the unglaciated sections with highly dissected terrain, seepage is encountered on hillsides at those points where surface soils intersect with impervious layers. Observations in east-central Ohio have shown that seepage can occur on both slopes of a ridge at these intersections. Further downslope, intersections of pervious and impervious strata occur under valley fills or slumps and may cause flows directly into stream channels or through alluvium to outlets above the main channels. The phreatic divides are usually dependent on lines of truncation or intersection, so it is often difficult to assign subsurface runoff to a specific catchment area.

It has been noted further that subsurface stormflows may be dissimilar on any given section, depending upon the hydraulic conductivity within a given profile and whether the flows are occurring through homogeneous soils, soils cut up by fissures and root channels, or through gravel pockets underlain by less pervious strata.

Numerous workers reporting on runoff or soil moisture studies have reported or implied the presence of subsurface stormflow in their study areas. Hertzler, Hoover, Hursh and others have reported on subsurface stormflow in the southern Appalachians. It was estimated that approximately 90 percent of the runoff from Coweeta drainages occurred as seepage.

However, few physical attempts at measuring subsurface stormflow are known. Hursh and Hoover reported on a study where subsurface stormflow was measured with a cutoff in a bank-face. A more recent attempt at measurements of subsurface stormflow is being made at the Coshocton Hydrologic Experiment Station, where a weir has been installed to measure flow from a seep spot on a forested watershed.

Barnes, Hursh and Brater, Tripp and Whelan, and Zingg are among the workers who have reported on measurements of subsurface stormflow by hydrograph analysis. Although hydrograph analyses are useful in subsoil water management research, their application is limited because

the methods used are arbitrary and the selected parameters may change from storm to storm on a given watershed. Until actual quantitative measurements of subsurface stormflow are available, the main value of quantities and rates derived from storm graphs will be theoretical.

Studies of Underground Water Movement and Permeability

The problem of studying subsurface stormflow from forested, hilly areas has a recognizable counterpart in the research currently directed at the drainage of agricultural lands. In this field, the work has been attacked largely by soil physicists and drainage engineers, with both lab and field studies. Even though there are obvious differences in the problems and objectives involved, some of the research findings will be helpful and possibly directly applicable to subsurface stormflow from forest soils.

The concept of the ideal or isotropic soil, where the soil body was homogeneous and flow was along one plane in an unchanging direction, was used in earlier drainage research. However, since field soils are largely heterogeneous in nature, the physical principle of anisotropy was introduced to include soils having different hydraulic conductivities in different directions.

The structural fissures in soils may develop more freely in one direction than in others--prismatic or columnar structures have a greater amount of vertical fissures whereas platy structures may have horizontally-oriented fissures. The principle directions in anisotropic soils are usually horizontal and vertical to the bedding planes. It has been found that unless there are geologic or biologic fissures in the vertical direction, hydraulic conductivity is greater in the horizontal bedding plane.

Most of the practical drainage work to date has been with anisotropic soils, with both uniform and layered horizons. And much of this research has been concerned with derivation of the hydraulic conductivity constant "K" for use in the Darcy equation.

Briefly, Darcy's equation (or law) states that the velocity of flow through a porous medium is directly proportional to the hydraulic conductivity "K" of the medium times driving force (or hydraulic gradient). The hydraulic conductivity of the soil is a function of soil particle size, and the amount and nature of the soil pore spaces.

Measurements of hydraulic head (for determining the hydraulic gradient) are made using the summation of velocity head, pressure head and datum head as given in the Bernoulli theorem. However, since the velocities of flow in drainage situations are almost always low, velocity head becomes negligible, and pressure head and datum head

are the most important. (This may not be true in subsurface stormflow from forested slopes, since appreciable velocities have been observed in places.)

Flow patterns are helpful for the interpretation of hydraulic head measurements. These flow patterns, using lines of equal hydraulic head (equipotential lines) and lines of directional flow (streamlines) have been constructed both theoretically and empirically. Model tests, using electrical analog and dyes, and field tests using small-bore wells and piezometers appear to check closely with theoretical flow nets. (Much of this theoretical work has been done by Childs, Kirkham, Luthin, Day, Maasland, and others. For those particularly interested, much of this theoretical work has been summarized in "Drainage of Agricultural Lands, Volume 7, American Society of Agronomy Series.")

The immediate application of the above to practical drainage problems is in the design and spacing of drains in high water table soils.

Of more immediate interest and applicability to the subsurface stormflow problem are the field methods used for measuring hydraulic conductivity in saturated soils. Essentially, these techniques consist of measuring rates of flow into a cavity at the base of a partially emptied tube, well, piezometer, or auger hole below the water table. The rate of recovery to static equilibrium is then related to dimensions of the sampling hole and to the hydraulic conductivity "K" of the soil.

The field methods for determining soil permeability appear to have greater value and reliability than laboratory methods--for the variation of homogeniety within a given area gives a statistical sampling problem when small "undisturbed" cores are used. Reeve and Kirkham have shown that the piezometer and auger hole methods give the truest measurements of horizontal permeability, when compared to the various methods mentioned above.

Drainage Studies With Some Immediate Application To The Subsurface Stormflow Problem

Practically all the drainage work up to the present has been concerned with the drainage of water tables in level agricultural soils. This, of course, is not the situation in subsurface stormflow from forest lands. In one study, however, Kirkham installed piezometers and small-pipe wells in batteries down a slope where numerous seep holes and subsurface flows were known to occur.

Objectives were:

(a) determination of perched groundwater table levels,
(b) direction of groundwater flow,
(c) coefficients of hydraulic conductivity down the slope.

The accretions and recessions to these perched water tables were studied from spring to fall of one year. Flow at the top of the hill had a downward component, at the middle of the hill a horizontal component and at the base of the hill, an upward component. No attempt was made to study the water level fluctuation of these wells during storm periods, but the falling limbs of the derived groundwater hydrograph (immediately after an accretion period) were similar to that portion of the stream recession curve when channel storage is being drawn down.

In the above study, instrumentation difficulties were encountered because the pipes were driven and the holes augered. Later studies of piezometer installation by other workers have shown that jetting methods of pipe installation may reduce the compaction and cavitation difficulties encountered by Kirkham.

Although large amounts of subsurface stormflow may come from temporary water tables in the forest soils, there's some indication that subsoil flow may also occur through the soil horizons above the water table. Luthin and Day and Swartzendruber and Kirkham have recognized that lateral subsurface flow is not necessarily limited to that region below the groundwater table and have studied flow above the phreatic or groundwater line. To date, this work has been done with laboratory models.

It was found that the capillary fringe area contributed substantial flows and that hydraulic conductivities were similar for some distance above the water table. During the "non-storm" periods when the capillary fringe was at a minimum, the water tables were essentially level. When inflow was added so that the capillary fringe increased and flow occurred, the water table rose toward the inflow end. Because of a hysteresis effect, flows were greater when the fringe was wetted from above than when the fringe was supplied from the groundwater table below.

The above are examples of pertinent drainage research findings being reviewed and investigated by the technicians in Ohio. As more knowledge of subsurface stormflow is gained on the ground, the theoretical and practical drainage research findings will become more valuable and applicable to our own situation. In the next several years a complete review of existing literature on drainage and groundwater hydraulics will be attempted in order to tie field observations to existing information.

Field Studies

As a start in field observation of subsurface stormflow, a study is being prepared in which the movement of water through a large, isolated block of forest soil will be measured. The initial soil series to be investigated is the Muskingum silt loam. Depths and intensities of "rain" will be controlled and outflow from the block face will be measured by cutoffs inserted at several horizons. This may give some insight into the hydrograph of flow resulting from various depths of rainfall at varied antecedent conditions. Instrumentation and flow condition problems are foreseen, but these are considered a part of the study. In addition, soil moisture measurements will be made and soil physical properties determined. It is hoped that the Chicago-Nuclear soil moisture meter can be used in these studies, along with piezometers or auger-hole wells. It is planned eventually to investigate subsurface storm flow not only on plots, but also on small watersheds and in the laboratory with model tanks. Along with this, broad geologic and soils groups within representative areas will be surveyed (both on watersheds requiring watershed management treatment and on watersheds now under good treatment). The ultimate objective, as mentioned earlier, is to find if "remedial subsoil" treatments are possible for reducing subsurface stormflow and getting more storm water into the deep ground water table.

Solicitation

It is hoped that these thoughts, aims, observations, and review findings will evoke comments, suggestions, and leads to help in the problem.

PLANTATION INFLUENCE ON STORM AND NON-STORM WATER YIELD

L. W. Hill

Watershed 172,[1/] a 43.6 acre, gaged watershed at the Soil and Water Conservation Research Station, Coshocton, Ohio, has been under observation since 1938 to obtain precipitation and runoff data. A dual-Parshall flume was constructed in 1938. Prior to installation of the flume, 2/3 of the watershed had a stand of grass and brush and 1/3 had a stand of uneven-aged hardwoods. In 1938 and 1939 the non-forested area was planted; primarily with white, red, and pitch pine. Three small areas were planted with black locust.

1/ See Semiannual Reports of the C.S.F.E.S. for October 1956-March 31, 1957, October 1, 1957-March 31, 1958, and April 1, 1958-September 30, 1958, for other reports on Coshocton Watershed 172.

The period of record for this study covers 11 years, from 6/1/39 - 5/31/45 and 6/1/52 - 5/31/57. The hydrologic water year--determined by regression analysis of P vs. RO to be June 1 through May 31--was divided into three hydrologic seasons as follows:

May 1 through September 30: Growing season or period of maximum evapo-transpiration.

October 1 through December 31: Period of soil moisture recharge.

January 1 through May 31: Period of ground water recharge.

The technique for separating the storm hydrograph is described in an article by Hursh and Brater on page 863 in the 1941 issue of A.G.U.

The 11-year average runoff is 11.10 inches with 2.22 inches (21 percent) as storm water yield and 8.88 inches (79 percent) as baseflow or non-storm water yield (Tables 1 and 2). The 1939-1945 period of plantation development (1-6 years old) exhibits nearly the same ratios. Of the 14.44 inches of total runoff, 1/5 was storm water yield and 4/5 was baseflow, or 2.97 and 11.47 inches, respectively.

Table 1.--Annual Precipitation and Runoff, Coshocton Watershed 172.

Hydrologic Year	Yield in Inches			Gross Precipitation
	Total	Stormflow[1/]	Non-Stormflow	
1939	13.53	1.42	12.11	36.94
1940	16.70	3.82	12.88	38.87
1941	16.98	3.60	13.38	41.11
1942	16.96	2.89	14.07	35.85
1943	8.38	1.23	7.15	30.10
1944	14.08	4.83	9.25	38.53
1952	4.50	0.81	3.69	30.37
1953	2.06	0.33	1.73	25.96
1954	6.93	1.11	5.82	32.81
1955	10.45	2.19	8.26	38.42
1956	11.44	2.15	9.29	35.68
Ave. 1939-44	14.44	2.97	11.47	36.90
Ave. 1952-56	7.08	1.32	5.76	32.65
11-Year Ave.	11.10	2.22	8.88	34.97

1/ Includes channel precipitation and subsurface stormflow.

Table 2.--Average Monthly Precipitation and Runoff, Coshocton Watershed 172.

Month	Precipitation[1]		Runoff[2]		
	Gross Precip.	No. of storms	Stormflow	Non-Stormflow	Total flow
June	4.21	7.9	0.27	0.60	0.87
July	4.33	7.4	.14	.33	.47
August	2.87	4.2	.09	.09	.18
September	2.54	3.8	.002	.09	.092
October	2.32	4.6	.013	.15	.163
November	2.33	4.8	.039	.30	.339
December	2.17	4.2	.092	.47	.562
January	2.76	4.1	.038	.60	.638
February	2.26	4.4	.16	.85	1.01
March	3.41	6.9	.65	2.05	2.70
April	3.21	8.2	.32	1.98	2.30
May	4.27	8.2	.41	1.37	1.78
Total	36.68	68.7	2.224	8.88	11.104

1/Averages based on the period 6/1/39 - 5/31/57.
2/Averages based on the combined periods of 6/1/39 - 5/31/45 and 6/1/52 - 5/31/57.

Values of storm and non-storm water yield for the 1952-1957 period of plantation development (13-17 years old) are also very close to the 11-year average, 1.32 inches as storm water yield and 5.76 inches as baseflow out of 7.08 inches of total runoff. Thus annual streamflow is still largely controlled by baseflow and there has been but little change in the proportion of total streamflow contributed by storm water yield or baseflow as a consequence of plantation establishment in 1938 and 1939.

However, total water yield has decreased. These changes were derived by regression analysis of precipitation vs. total, storm, and ground water runoff, Table 3.

Table 3.--Estimated Inches of Decrease in Water Yield between 1939-1945 and 1952-1957 by Hydrologic Seasons, Coshocton Watershed 172.

Yield	Total	Hydrologic Seasons		
		Evapotranspiration	Soil Moisture Recharge	Ground Water Recharge
	(in.)	(in.)	(in.)	(in.)
Storm water	1.44	0.17	0.21	1.06
Non-storm water	4.42	1.01	1.32	2.09
Total	5.86	1.18	1.53	3.15

The total decrease in water yield between the two stages of plantation development is 5.86 inches with 24.6 percent accounted for in storm water yield and 75.4 percent in non-storm water yield.

The greatest difference occurred during the ground water recharge period--both for storm and non-storm water yields. The largest difference, 2.09 inches of non-storm water yield, reflects the effect of reestablished vegetation upon storage of water on the watershed. Evapo-transpirational drains increase as the plantation develops leaving less moisture in the soil per unit of rainfall. Consequently higher field moisture deficits result in the soil moisture recharge period during later stages of plantation development. These deficits must be satisfied during the soil moisture recharge period before gravitational water can reach the ground water table. Thus less water is now available to become gravitational water and to reappear as baseflow during the ground water recharge period.

Storm water yields during the season of ground water recharge are 1.06 inches less during the 1952-1957 period than during the 1939-1945 period of plantation development. This is probably due to the moderating influence of the plantation on frost occurrence in the ground, to an improvement in the structure of surface soil layers and to the build-up of a humus and litter layer. Hence, there is a greater opportunity for precipitation to infiltrate and move through deeper soil layers before it reaches the stream channel.

Storm water yields computed from data collected during this study when compared with similar information on other streams suggest that stormflows on forested headwater drainages are quite variable, Table 4. An increase or decrease in total runoff is not necessarily accompanied by a corresponding change in storm water yield.

Storm water yields vary from 9 percent (Coweeta 13) to 55 percent (Beaver Creek) of the total annual runoff. Variation may be due to any one of several reasons, only a few of which are evident from data presently available. It may be that the ratios of storm and non-storm water yields to total yields are fixed by physiographic regions, geologic formations, or precipitation belts. Further research with this in mind may help to catagorize storm and non-storm values and serve to pin-point watershed characteristics which influence them.

Table 4.--Precipitation and Water Yields for Selected Forested Watersheds in the United States.

Watershed	Area (acres)	Gross Precip. (in.)	Water Yield (Inches): Total	Storm	Non-Storm	Period
Coshocton 172	43.6	32.65	7.08	1.32	5.76	1952-57
Coshocton 172[1/]	43.6	36.90	14.44	2.97	11.47	1939-45
Coweeta 13	40.0	71.26	40.87	3.66	37.21	1937-52
White Hollow (Tennessee)	1,715	45.16	16.84	5.62	11.22	1945-49
White Hollow (Tennessee)	1,715	33.61	15.95	6.15	9.80	1936-47
Beaver Creek[2/] (Missouri)	8,960	37.69	12.95	7.13	5.82	1948-55

1/ 1/3 forested, 2/3 in pine plantation established in 1938 and 1939.
2/ 2/3 forested, 1/3 open.

RAMPAGING WATER

Man uses relatively small amounts of water every day to sustain life upon the earth. But nature does not always furnish water in useable, small amounts. Such was the case in the Central States on January 21, 1959. Much has already been written of the floods that did 100 million dollars damage in Ohio on that date. And, much more remains to be reported from the many studies being made by federal, state and local authorities.

Meteorological conditions which caused the heavy downpour of rain have a return expectancy of once in a hundred years (Pierce,1959).[1/] Combining were a strong flow of super-moist and warm air from the southern seas, a new and rapidly developing storm center to the southwest, and a warm front just south of the Ohio River. The combination was vigorous during the late p.m. of January 20 and the early a.m. of January 21. The warm front rushed northward across Ohio as the new low pressure center moved northeastward. A zone of convergence developed 50 to 100 miles southeast of the front. Rapidly

1/ Pierce, L. T. 1959. What caused the flood? Ohio Farmer, Febr. 21, 1959, p. 24.

rising air currents from this convergence resulted in heavy thundershowers and intensive rainfall. At the Columbus airport, for example, the rain which started to fall just before midnight totalled 4.79 inches by the next noon. Since a five-inch rainstorm in 24 hours has a return expectancy in this area of once in a hundred years, this storm was rather unusual in total amount.

The temperature conditions were also unusual. Temperatures had been low for several days because of a preceding snowstorm. Therefore, much of the soil was frozen solidly several inches deep. Temperatures rose rapidly during the early a.m. of January 21 because of the great mass of warm moist air from the Caribbean Ocean and the Gulf of Mexico. And, though they rose into the low 60's, only the upper inch or so of the deeply frozen soil thawed out before the storm was all over.

The peaks of the resulting floods were, therefore, dependent upon two things: heavy rainfall and frozen ground (Wray, 1959).[1/] In many places most of the rain ran over the land as fast as it fell. These places were the open areas with concrete frost. And, observations on such areas in east-central Ohio two days before the storm showed they had three inches of concrete frost. But, the soil under good hardwood forests near by had no concrete frost at all. This means that the rain that fell on forest land did not run off immediately but was at least temporarily delayed. Thus peak rates could have been higher if the water from the forested areas had not reached rivers and streams some time after that from the frozen ground of open areas.

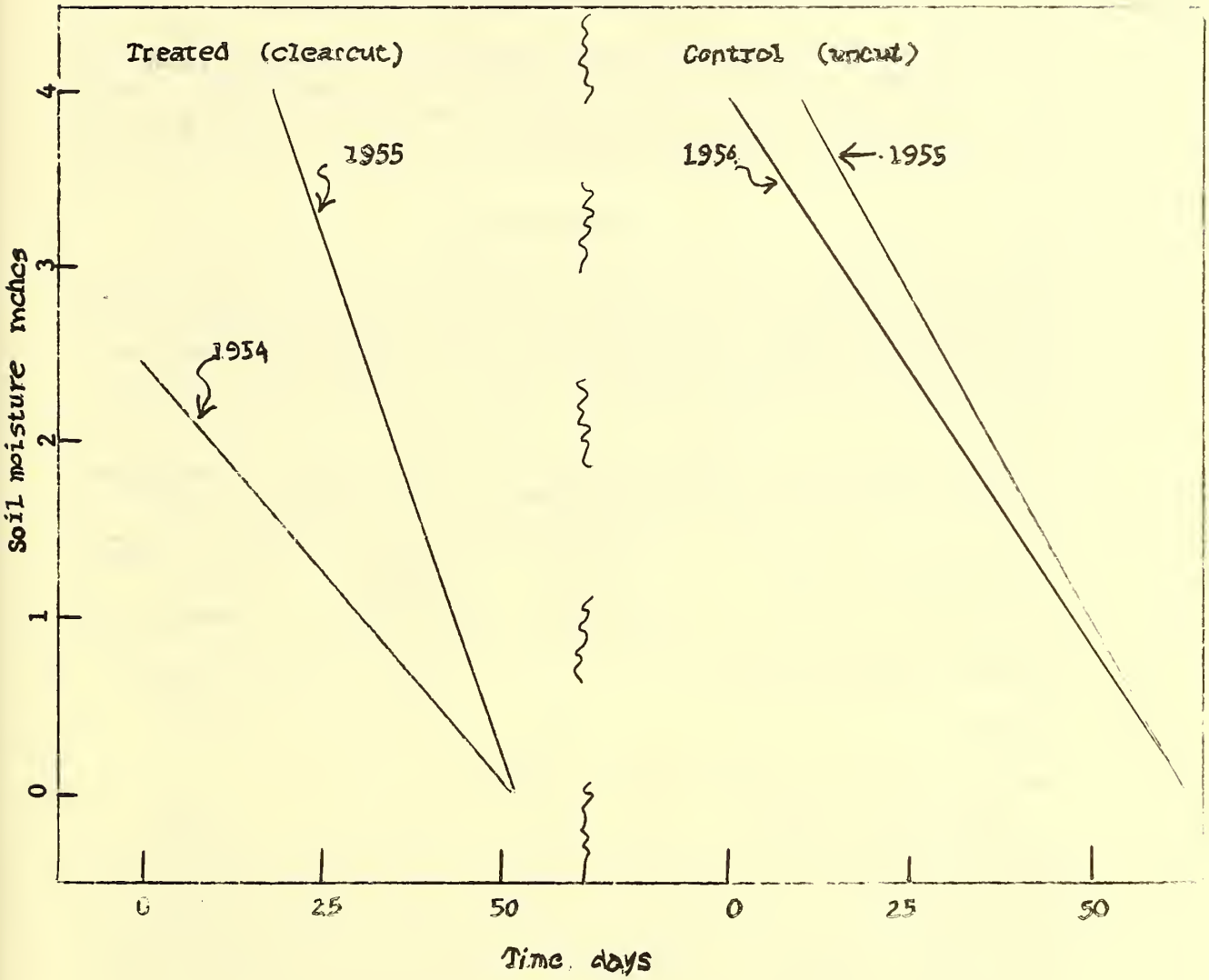
EFFECT OF CLEARCUTTING A POOR-SITE OAK STAND UPON THE SOIL MOISTURE DEPLETION CURVE

Further consideration of the soil moisture trends under clearcut and uncut poor-site oak stands in southeastern Ohio suggested the construction of "mean" or "normal" growing-season, soil-moisture, depletion curves. (The "mean" or "normal" streamflow depletion curve represents, according to Johnstone and Cross,[2/] the depletion that would result over a long dry period.) Mean soil moisture curves were constructed according to the method they describe, Figure 1.

1/ Wray, Robert D., 1959. Floods, Frost, and Forests. Submitted for newspaper publication.

2/ Johnstone, Don and William P. Cross, 1949. Elements of Applied Hydrology. The Ronald Press Company, New York.

Fig. 1--"Mean" or "normal" growing season soil moisture depletion curves, clearcut and uncut, poor-site oak stands, southeastern Ohio, 1954-1955.



These curves reveal:

1. Depletion curves are linear. This is logical since the evapotranspiration demand for soil moisture is fairly constant during rainless periods as long as soil moisture is readily available. This is unlike streamflow depletion curves because the latter vary directly with the amount

of available ground water--the amount of flow per unit of time diminishes as time increases.

2. Depletion under the control condition was quite similar in rate and amount during both years of the study.

3. Depletion under the treated condition was slower and less in amount than the control during the first year (1954), but was faster, greater in quantity, and somewhat similar to the control during the second year.

NEUTRON METERS

Stop-watch timed, probe-in-shield readings from five neutron, soil-moisture meters show that some meters give much more consistent readings than others. Variation from most of the instruments was less than the performance rating claimed for the meters, but at least one was greater, Table 1.

Table 1.--Variation between successive probe-in-shield readings on five neutron soil-moisture meters.

Location of meter	Number of readings	Length of reading (minutes)	Range divided by mean
Wasatch Research Center	7	2	.105
Coweeta	30	1	.059
Georgia Coastal Plains Experiment Station	20	1	.079 1/
Coshocton, Ohio	30	1	.042
San Dimas	30	2	.075

1/ Nuclear-Chicago scaler with Van Bavel type probe.

MEETINGS

October 1-2. Society of American Foresters National Meeting. Marston.

October 19-22. Soil Conservation Society of America National Meeting. Johnson and Marston.

October 28-29. Watershed Management Training Meeting for Iowa State Foresters. Johnson.

October 27-31. Conference on Methods and Techniques of Measuring Understory Vegetation. Marston.

November 10. P.L. 566 Work Plan Review, Upper Wabash Watershed. Marston.

December 28-29. AAAS Meeting Section "O" Water and Agriculture. Johnson.

January 19-23. Watershed Management Research Conference. Johnson and Marston.

February 24-25. Inspection of portions of flooded and forested areas in northeast Ohio. Johnson, Marston, Hill, Roach, Whipkey.

March 16-18. Editorial Board Meeting, Journal of Soil and Water Conservation. Washington, D. C. Johnson.

March 23. Discussion of watershed protection phase of proposed P.L. 566 Program, Chippewa Watershed. Marston.

MANUSCRIPTS

Wray, Robert D. Floods, Frost, and Forests. Submitted for newspaper publication.

PERTINENT LITERATURE

Bonner, James 1959. Water transport. Science 129: 447-450. A logical discussion of the absorption into and transport of water through plant tissues. Compares resistance to water movement by assigning unity to resistance of movement from liquid water into and through roots. Then the resistance to movement through a meter of stem is of the order of 0.1 to 0.02, but the resistance from water surface to water vapor in the air is 1 million or more.

Chieruzzi, Robert and Robert F. Baker 1958. A study of Lake Erie bluff recession. Ohio State University Engineering Expt. Sta. Bul. 172, Vol. XXVII No. 6, 100 pp., photos, charts, diagrams, biblio. A report of specific study but contains a good theoretical development and proposes practical soil stabilization methods applicable elsewhere.

Linsley, Ray K., Max A. Kohler, and Joseph L. H. Paulhus 1958. Hydrology for engineers. McGraw Hill Book Co. 340 pp.

A clear presentation without involved mathematical derivations. A college text book type arrangement with problems at the ends of the chapters.

SEMIANNUAL REPORT ON WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station

October 1958 - March 1959

GENERAL

While the east reeled under continuing onslaughts of winter storms that heaped snow upon snow, the Intermountain region basked in almost "banana-belt" weather. But pleasant though the temperatures, this region is faced with below normal water prospects for the summer just ahead. Snowpack measurements throughout the region indicate the water supply to be only 50 to 75 percent of the normal.

Copeland and Paul Packer attended the Watershed Management Research Conference at the San Dimas Experimental Forest, January 19-23. A vote of thanks is extended to the California Station personnel for hosting the conference in such an excellent manner.

All WMR personnel of this Station participated in a four-day training session in Ogden, February 17-20. In attendance were Paul Packer, Joe Kidd, Harold Haupt, Richard Meeuwig, Dale Pfankuch, Allie Blain, and Copeland.

Publications during the past six months include:

Packer, Paul E. 1958. Management of forest watersheds and improvement of fish habitat. Trans. Amer. Fisheries Soc. 87:392-397.

Craddock, George W. 1959. Watershed management problems of the Intermountain West. Proc. Soc. Amer. Foresters 1958, pp. 31-32.

Marston, Richard B. 1959. Use of a nuclear soil moisture meter in studies of evapotranspiration on mountain soils. Proc. Soc. Amer. Foresters, 1958, pp. 39-41.

BOISE RESEARCH CENTER

General

During October a show-me trip for Professors Fred Johnson and Howard Loewenstein of the College of Forestry, University of Idaho covered the foothill range at Arrowrock Substation, the Boise Basin Experimental Forest, and the Beaver Creek and Little Owl timber sale areas on the Boise National Forest.

In January, Kidd attended a one-day meeting at the University of Idaho held by the University Engineering Research staff to discuss telemetering of meteorological data from remote sites. Representatives of other government agencies and private industry also attended.

Two watershed areas are receiving consideration as possible sites for a new study of the "erosional and hydrological effects of cutting ponderosa pine on steeply sloping granitic soils." In November, the Silver Creek area on the Boise National Forest was examined, both from the air and the ground; while in February, the Tailholt drainage (near Zena Creek on the Payette National Forest) was ground-checked. An observational survey type of study is planned for the Zena Creek-Tailholt Creek area provided the special timber sale plans materialize; possibly a more intensive study can be started on Silver Creek in the near future.

A brief summary of activities relating to various studies follows:

1. Little Owl logging road reseeding study (FS-1-w6-3)

   Additional data on variables such as aspect, percent of plot shaded during afternoon hours, and road cut height as related to road surface soil type were examined for possible use in a covariance analysis of data pertaining to seedbed treatment. Insufficient correlation was found to warrant an additional analysis of covariance. A final report and research note are now being written for this experiment.

2. Skidtrail structures study (FS-1-w6-3)

   Qualitative and quantitative data concerning soil erosion and revegetation on skidtrails of national forest timber sale areas are being analyzed. A report showing the relative effectiveness of several types of erosion control structures and recommendations for proper spacing on slopes of different steepness will be completed this spring.

3. Modified logging methods (FS-1-w5-2)

   An outline for a study plan for this new study was prepared during the winter. The study is concerned with the effects of logging ponderosa pine on steep slopes by several methods such as jammer, mobile spar, or high lead.

W. J. Kidd

GREAT BASIN RESEARCH CENTER

Pleasant Creek Restoration Program Evaluation Study (FS-1-w6-1)

Pleasant Creek has flooded about 20 times in the past 65 years causing damage to the town of Mt. Pleasant, Utah and surrounding farmland amounting to more than $300,000. All of these floods occurred during the summer months as a result of high-intensity rains falling on headwater slopes depleted by overgrazing and livestock trampling.

Restoration treatments on the depleted subalpine slopes, where most of the flood waters originated, were begun in 1950 and completed in 1957. Treatments included grazing exclusion, disking, contour trenching, seeding, and gully plugging.

In 1955, the Great Basin Research Center was assigned responsibility for planning and supervising a study to evaluate the effects of the restoration treatments in cooperation with the Manti-LaSal National Forest and the Soil Conservation Service. This study involves comparison of 1955 pretreatment measurements of infiltration and soil stability, slope and channel erosion, and plant and litter cover with those of 1958, 3 years after treatment. The 1958 phase of this study has just been completed. Because of the short time-period involved, results are not fully conclusive, but the following generalizations are believed warranted.

Disking and contour trenching destroyed many of the shoestring gullies extending down the slope. These treatments formed numerous detention depressions in opposition to the gully pattern, and eliminated most of the rapid gully drainage and reduced overland flow.

Artificial restoration has increased initial infiltration but decreased final infiltration. The reduced final infiltration is attributed to pore sealing brought about by partial breakdown of soil structure due to disking. However, studies at the Great Basin Research Center of high-intensity summer storm patterns show that the highest intensities of such storms usually occur in the first few minutes. In this case, higher initial infiltration is of prime importance and lower final infiltration is expected to be of less consequence. Results from infiltrometer studies also indicate that disking has reduced surface soil stability temporarily, but this temporary condition is not serious if overland flow is kept in check. The higher initial infiltration capacity and the contour trenches provide reasonable assurance that overland flow under natural rainfall conditions will be controlled. Both soil stability and final infiltration capacity are expected to increase as soil structure improves.

Live plant cover density on treated areas has increased to about 1½ times its pretreatment density in the 3 years since treatment. Litter

cover density was reduced by disking and has not built up to its original level yet, but, under proper management, can be expected to increase beyond its original density in the next few years.

Sediment production during the first 3 years after treatment was slightly higher on plots that were disked and seeded but lower on plots that were contour trenched but not disked than on untreated control plots. This indicates that contour trenches are effectively controlling overland flow and erosion while the seeded grasses are becoming established and the soil is becoming restabilized.

Measurements of channel cross-sections showed that channel erosion was much less below treated slopes than below untreated slopes. The reduction in channel erosion below treated slopes is attributed primarily to the control of overland flow by the contour trenches.

Repeat measurements scheduled for 1961 are expected to provide still clearer indications of the long-range effects of artificial restoration.

Richard O. Meeuwig

MISSOULA RESEARCH CENTER

Work at Missoula Research Center during the past winter has been restricted almost entirely to compilation and analysis of data.

Snow behavior (FS-1-w1-2)

Analysis of the snow accumulation data from Priest River Experimental Forest was completed using the 650 IBM computer at Washington State College. This analysis revealed that an 8-variable polynomial power series best describes the relationship of maximum winter snow water equivalent to elevation, aspect, and forest cover condition. The relationship to elevation involves a polynomial of the first three power functions. This means that maximum water equivalent is related to elevation by a cubic curve having a minimum and a maximum point and one inflection. A similar type curve describes the relationship with aspect. A quadratic of the first two powers indicates that maximum water equivalent and forest canopy density are parabolically related, water equivalent decreasing with increasing forest density.

The relationship of elevation, aspect, and forest cover to snow water ablation during the spring melting period is in process of being set up for analysis on the 650 computer very shortly. Processing of all of the snow behavior data has moved slowly because of the large mass of data involved and very limited manpower resources with which to handle it. The data, covering 4 years of record, involves 1,242 station years of data including five elevational zones, six aspects, and five forest cover classes.

Road development guides (FS-1-w5-3)

Data on two dependent and 22 independent variables relating erosive cutting of road surfaces and sediment movement downslope from roads to topographic, and road construction watershed variables on 600 study sites in Region 1 have been summarized preparatory to programming and analysis on the 650 computer. Unfortunately, this service cannot be contracted until the new fiscal year due to the WMR project's state of financial depletion between now and July 1. Plans have been made for continuing the field work on the remaining two soil groups which were not completed last year.

Analysis of soil samples from last season's work on five soil groups has been proceeding slowly but meticulously in the soils laboratory at Montana State University. This analysis should be completed in time to meet the schedule for IBM analysis.

Paul E. Packer

NEVADA RESEARCH CENTER

General

Haupt attended the 12th Annual Nevada Water Conference at Carson City on October 23-24. He presented a proposed research program for the Walker, Carson, and Truckee River basins.

Wanted

A small, compact "snow buggy", transportable on a trailer pulled behind a jeep, capacity two men with light equipment, climbs at least a 20-percent slope, requires little maintenance after occasional round trips of 4-8 miles.....initial cost less than $1500. In all seriousness, I would be interested in any information on such a vehicle, if it exists. Please write: Nevada Research Center, Rm. 326, M. C. Fleischmann Bldg., University Station, Reno.

Road development guides (FS-1-w5-3)

In the October 1956-March 1957 Semiannual report, we outlined three equations upon which we are basing the approach for controlling sediment from logging roads on ponderosa pine lands of southwestern Idaho. This approach includes predetermining (1) the width of protective strip to leave below a new logging road and (2) the treatment to give to the road and protective strip so as to confine future road sediment within the downslope area. After reviews and revision progress was made in enlarging this idea into a prediction method that can be used readily by road locators and erosion control specialists.

The main equation derived beforehand was:

$$\text{Sediment flow distance (Sfd)} = 1.2871(\text{Soi}) + .0030\ (\text{Cdi})^2 + 3.4918(\text{Esl}) + .0468(\text{Cdi} \cdot \text{Rg}) - 66.2395$$

Substitution in this equation and solving for Sfd provides the basis for applying the prediction method on timber sale areas. Although oversimplified, the following procedure shows how this substitution is made. Slope obstruction index (Soi) is chosen as the maximum spacing of slope obstructions found on a given exposure; this spacing usually increases from north to south aspects but may be reduced by placing logging slash between the natural obstructions. Cross ditch interval (Cdi) comprises some safe minimum spacing, like 30 feet, which is used at the time of road location. Because embankment slope length (Esl) is related to side slope topography, the latter measurement is used when locating a road. The road gradient (Rg) is somewhat inflexible, being the grade needed for gaining access to timber to be cut.

So that the road locator will have a quick and accurate check against positioning too much of any new logging road too close to a drainage course or lower road, the equation is solved beforehand in the prediction method and the values expressed in table 1.

Table 1.--Minimum slope distance to center line of the proposed road

Road gradient	Side slope gradient -- percent									
(Percent)	20-28	29-37	38-46	47-55	56-64	20-28	29-37	38-46	47-55	56-64
	Minimum Distance to center line -- feet									
	North aspect					East aspect				
1-3	20	40	50	70	90	40	50	70	80	100
4-6	30	40	60	70	90	40	50	70	90	100
7-9	30	50	60	80	90	40	60	70	90	110
10-12	30	50	60	80	100	50	60	80	90	110
	West aspect					South aspect				
1-3	50	60	80	100	110	60	80	90	110	130
4-6	50	70	80	100	120	60	80	100	110	130
7-9	60	70	90	100	120	70	80	100	120	130
10-12	60	70	90	110	120	70	90	100	120	140

This table gives the predicted sediment flow distance or, expressing it in another way, provides the minimum width of protective strip required, depending upon the maximum (or limiting) side slope gradient and road gradient to be encountered on a slope exposure. Thus, the locator flags the road and should attempt to remain at least this minimum distance from the stream channel at every point along the proposed road. Should the locator deem it necessary to locate a section of road less than the minimum distance to center line, it is implied that the ultimate cross ditch spacing along this critical stretch of road will be 30 feet, and that the slope obstruction index will probably have to be reduced with slash.

For treating roads after cessation of logging operations, the prediction equation again is readily adaptable by considering the existing distance across the protective strip to equal Sfd and solving for either cross ditch interval or slope obstruction index. The method also affords a way of intensifying the degree of treatment as the slope distance between road and channel decreases. The purpose is to be doubly certain that sediment movement from roads will not traverse even the very narrow strips. Five intensities of treatment are prescribed, depending upon the width of protective strip.

1. Roads with protective strips greater than 200 feet should not have any two cross ditches spaced farther apart than 130 feet, regardless of side slope gradient (or embankment slope length), road gradient or slope exposure.

2. Where roads have protective strips less than 200 feet, observations of on-the-ground factors is necessary before selecting the maximum permissible cross ditch spacing. In addition to estimating the actual width of protective strip, slope exposure, embankment slope length, and road gradient are also observed.

3. Where the width of protective strip is less than 120 feet, some combinations of factors (especially on more erodible south slope exposures) give a permitted cross ditch spacing of 30 feet. Consequently, the protective strips below these 30-foot ditches may require improvement of the slope obstruction index. Such factors as road gradient, embankment slope length, and width of protective strip determine the minimum number of slope obstructions required below each cross ditch.

4. Where the width of protective strip is less than 60 feet, some combinations of factors again on critical south exposures require additional treatment measures, such as "contiguous obstructions." Fortunately, such combinations of factors can be held to a minimum if the road locator has used table 1 judiciously at the time of road layout. Nevertheless, there are places near channel crossings,

at road junctions, or on switch-back turns, where protective strips are narrow and therefore require some extra erosion control treatment. For instance, the treatment contiguous obstructions calls for the placing of obstructions less than 1 foot apart across the direction of slope below the cross ditch outlet.

5. Where the protective strip approaches zero width at the intersection of a road and stream channel, effective sediment control may be gained by bulldozing a wide "dip" in the road. This will remove much of the road fill material from the direct path of ephemeral or perennial streamflow.

For determining maximum permissible cross ditch spacing and minimum number of slope obstructions, appropriate tables (similar to table 1) were derived from the prediction equation for field use by the erosion control specialist.

How frequent are rain-on-snow events in the Truckee basin?

Historical records indicate that rain-on-snow floods occurred on the main Truckee in January 1862, December 1867, January 1868, January 1886, March 1907, January 1909, December 1913, March 1928, December 1937, November 1950, and December 1955. The '37, '50, and '55 floods established new peak discharge records in consecutive order. Recently, the Corps of Engineers stated that the 1950 and 1955 events were 100-year floods.

Streamflow-precipitation records available now for the Dog Creek demonstration watershed (16 sq. miles) reveal that the maximum peaks for 1957 and 1958 (the first two years of record) were caused by rain-on-snow events and not by snowmelt alone! This leads us to believe that these events may be much more common over small watersheds within than over the entire drainage basin. To illustrate, during February 22-24, 1958, western Nevada disaster control agencies were alerted for a main stem rain-on-snow flood which never came off. In the interim, the Dog Creek gage recorded an instantaneous peak of 550 c.f.s. at 8:00 p.m. on the 24th. About 24 hours before, the daily peak did not exceed 65 c.f.s. Over the same period more than 2.00 inches of rain fell on a snowpack which covered about 95 percent of the watershed at the beginning of storm.

Harold F. Haupt

WASATCH RESEARCH CENTER

Public relations

The education and public relations phase of the research program of this Center continues to be a stimulating and rewarding experience. This year, between 600 and 700 visitors from all over the world and with varying backgrounds were guided on tours of the Davis County Experimental Watershed.

For the second time in slightly more than a decade, this Center was field trip host to the members of the Society of American Foresters. On October 2, 1958 the day was bright, clear, and mild as a long line of two-ton trucks loaded with passengers departed from Salt Lake City.

On their way to the mountains, almost three hundred foresters saw some of the destruction that mud-rock floods have caused in the valley at the mouth of Parrish and Farmington Canyons. Soon after leaving the rock-covered fields, the long climb into the mountains on a steep, narrow, and winding road began. Up Farmington Canyon the caravan moved, past the spot where 6 people lost their lives in the flood of 1923. On the way, watersheds in good, fair, and poor hydrologic condition were viewed and the circumstances which brought about these conditions were explained.

From contour trenches overlooking Farmington flats, the group ate their chicken dinners and watched demonstrations of some of the latest types of forestry equipment and fire-fighting techniques.

After lunch, it was load up and climb some more. Up, up, and up until at last Bountiful Peak outlook, with its magnificent view of the Great Salt Lake, was reached. From here, one can fully appreciate the importance of these water-yielding high mountain watersheds to the people living in a semidesert region in the valley below. Here, at what seems like the top of the world, contoured and seeded lands that were once flood-source areas were inspected.

The next stop was the Parrish experimental plots. Studies concerning the requirements of plant cover to protect the soil from high-intensity summer storms and the consumptive use of water by vegetation were viewed and discussed.

Just after leaving the Parrish plots, each truck, homeward bound, passed through the head of Centerville Canyon. No floods have emanated from this Canyon in historic times. The lesson which is so clearly demonstrated here, and which is the goal of all conservationists is that with moderate and wise use, without abuse, we can reap the benefits of all the mountain resources without the penalty of disastrous mud-rock floods.

The Station and Center personnel are grateful for these opportunities to pass along information and display our work and the work of others that have preceded us. We hope this day fulfilled all the expectations of each and every one, and we extend to those who attended this S.A.F. tour and to those who did not, an invitation to visit and tour the Davis County Experimental Watershed with us.

In addition to the S.A.F. group, many other guided tours were conducted by Station and Center personnel. These groups varied in size from a single individual to as many as 70 persons.

Casual visitors to the watershed area number in the thousands. Most of these visits are for recreation, but a few are made specifically to see the experimental work being carried on at this Center. A number of place and information signs have been erected to help these people interpret the projects they view during their visit.

Parrish runoff and erosion plots (FS-1-w6-1

Parrish plot 7 was denuded in 1947 and has been kept bare for 12 summer seasons. During these 12 seasons, 52 storms have caused runoff. Total depth of these storms aggregates 32.33 inches. Slightly more than 14 percent of the summer precipitation has run off this 1/10-acre plot.

Thirty-five of the 52 storms caused both runoff and soil erosion. The total air-dried sediment lost from this plot to date is 244.58 cubic feet, or nearly 6.5 tons per acre per year.

Samples of the sediment produced by each of these 35 storms were collected, and are at present being analyzed for particle size distribution. Plans have been developed to relate the volume of runoff by soil particle sizes to such storm variables as total depth, duration, and maximum 5-minute intensity. This new study is scheduled for completion by July 1, 1959. If anyone has references to similar studies, I would appreciate it if you would send me the author's name, title, and publication source.

Dale J. Pfankuch

LAKE STATES FOREST EXPERIMENT STATION

WATERSHED MANAGEMENT RESEARCH SEMIANNUAL PROGRESS REPORT
October 1, 1958, to March 31, 1959

General

In late September and early October 1958 five members of the Watershed Management Division of the Lake States Station, i.e., Weitzman, Stoeckeler, Sartz, Bay, and Striffler, visited watershed research installations at Fraser, Loveland Pass, Davis County, Great Basin, Beaver Creek, Prescott, Sierra Ancha, and Globe. We are much indebted to the Rocky Mountain and Intermountain Stations' personnel for the time and thought spent in arranging these tours and for sharing their observations and experiences with us especially in the problems of new instrumentation.

Selection of experimental forests for watershed management studies in Lower Michigan and preparation of reports on them occupied much of Stoeckeler's time in the past 6 months. As of the current date, 3 different areas have been selected from an original list of about 20 that showed some promise. A detailed report was prepared on these areas to serve as a basis for preparation of a formal establishment report.

Some of these areas are unusual in the light of what is ordinarily selected for watershed management studies. They are almost flat, with as little as 20 to 30 feet of elevation difference in a distance of 3 miles and with a gradual change in depth to permanent water table.

A year of study in Europe is in the offing for Stoeckeler, who was awarded a Senior Postdoctoral fellowship by the National Science Foundation. He will study various aspects of afforestation of peat lands, the drainage of forested swamps, and its ecological and hydrological effects. The bases of operation for these studies will be Universities and Research Institutes in Stockholm, Helsinki, Munich, and Bremen. The information obtained on this study tour should be of value in shaping up studies in a virtually unexplored field of research in the Lake States; that is, in the watershed management and soil-site relations aspects of peat lands, of which we have over 10 million acres in the three Lake States.

La Crosse Research Center

Since our last report, written and typed (hunt and peck) by our one-man staff in temporary quarters, we have come quite a way. In November we moved to still temporary--but better--quarters in the post office building. Later that month we hired Miss Janice Johnson to run the shop--and a good choice it seems to have been. In January we brought on Willie Curtis from the Rocky Mountain Station's Beaver Creek Project at Flagstaff to be our acting project leader; and that same week we moved into permanent quarters in the post office building.

Research Area Selected

Final selection of an experimental area was made in November. Subsequently, the Wisconsin Conservation Commission approved purchase of the land by the State for our use. Under our co-operative agreement with the Wisconsin Conservation Department, the State is providing the land for our research. Since there is no suitable State-owned land in the Driftless Area, they agreed to purchase the land that we wanted.

The tract is some 2,500-3,000 acres of forest and farmland about half an hour from our office in La Crosse. About two-thirds is forested, the rest cultivated or pastured. Its soils, geology, and use are typical of the larger problem area. Small watersheds can be found draining in any of the cardinal directions. In short, we are happy with the area on all counts. We do not anticipate that the State will run into much opposition to sell. Most of the landowners have approached us, and most of them seem to be quite willing.

Appraisal crews from the Conservation Department will be ready to move into the field as soon as the snow is gone. Then it may be another 9 months to a year before the properties are finally bought.

Weather in the News

La Crosse is just now thawing out of its worst winter since the city was named after the game that the Indians used to play here. It was not only the coldest, but the snowiest. We had both a record winter's snowfall, and a record storm. The latter put down about 22 inches in our part of town. This wouldn't be news at Hubbard, Brook, at Fraser, or at the end of Al West's snow tube, but in La Crosse, Wis., which ordinarily doesn't boast of much snow, this was news. We measured an accumulated pack of 2 to 3 feet with water content of 6 to 8 inches. Water pipes were freezing at 4 to 5 feet in some places

before the heavy snow blanket began to build up. Record floods were predicted for some rivers, but the gradual thaw which we are having seems to have eased the threat as of now.

Runoff Study

To give us some preliminary figures on peak flows and sediment loads to be expected from various sizes of drainages, we put out five combination maximum peak gages and stage sediment samplers. The setup might be of interest. For the peak gages we used 3/4-inch galvanized pipe, threaded and capped on the top. We drilled 1/4-inch holes at about 8-inch intervals for intakes. The measuring device is 1/2-inch wide flat lathe used at the bottom of window shades. Eight-foot lengths were bought for a few cents each. These were cut to a little more than the expected height of the pipe above the channel bottom, and after the pipes were put in, were cut flush with the top. The sticks were painted white, and marked off in feet and tenths.

For the waterline indicator we used ordinary vegetable coloring. We used green, and fitted a felt pen in the end of the bottle so that a line about an eighth inch wide could be put on the sticks. We merely ran the "pen" along one of the two grooves that were already in the sticks, and this gave us a straight line. The vegetable coloring responds quickly to wetting but was not affected by any humidity that we have had here. After taking a reading, the stick can be wiped dry, and a new line put on right away.

For the sediment samplers we used square-faced pint milk bottles a la the St. Anthony Falls A-58B model. We bent the copper tubing with a hand bender which cost about 35 cents. The rigged up bottles were mounted on alternate sides in slots cut out of a 2 x 4 and fastened in place with pieces of sheet tin. We used three bottles on each 2 x 4 to sample at stage intervals of about 8 inches.

Holes were drilled near both ends of the 2 x 4 to fit eyebolts through which we could pass the maximum peak pipe, so the peak gage and stage samplers could be handled as one unit. We mounted the peak gages by driving the pipes in the channel bottom with a king tube hammer. This doesn't harm the threads on the end of the pipe. The sediment sampling units were mounted after the pipes had been driven in place.

Analysis of Old La Crosse Station Data

Under the late Carlos Bates, the Lake States Station built and operated ten 20' x 10' x 4' lysimeters here from 1935 to 1942.

We believe that these may have been the first large-size lysimeters built in this country. Different vegetative treatments were applied to the separate lysimeters, and surface runoff, ground-water yield, and soil loss were measured and recorded for 6 years. Because of the war and Bates' death in 1949, the results were never formally written up. Sartz is doing this now. To date he has just finished the compiling job. The results will be given later.

Soil Moisture Study

Soil moisture samples were collected on five occasions during the period from June through September 1957 in La Crosse County, Wis.

The study was initiated by J. H. Stoeckeler. Before its completion through the analysis and writeup stage, Stoeckeler was shifted to a nursery manual project. Consequently, the analysis and writeup was inherited by personnel of the new La Crosse Research Center.

The data are now in final stages of analysis and results should be available in the near future. The study involved a transect across a valley in an ungrazed oak wood, running from the top of slope to bottom and to top of next slope. North and south aspects were sampled. Another phase of the study involved open pasture and pine plantations on the two aspects.

Presentation of results will show soil moisture differences under comparable vegetative cover condition but on different aspects. Also moisture differences for same cover conditions and aspect but different slope positions will be shown.

Miscellaneous

Sartz prepared and delivered a talk on "Pointing forestry toward a more effective runoff and erosion control job in Wisconsin" at Farm and Home Week in Madison in January. Part of the paper was later written up as "Forests and Water: A Tale of Two Watersheds" to be published in the Wisconsin Academy Review.

--R. S. Sartz

Grand Rapids Research Center

General

Much of the time during the last 6 months has been spent gathering data and finishing a rough draft of a problem analysis for watershed management research in northern Minnesota.

Calculation and analysis of soil moisture and soil freezing data has received some attention also.

A soil freezing experiment was not carried on this past winter and we are now wondering whether or not it was a wise move. This has been one of the coldest winters on record in northern Minnesota. International Falls, Minn., with a long-term average temperature of about 0° F. had a January average minimum temperature of -16.5° F. Both large and small cities reported breaks in water mains, that were buried 5 to 6 feet underground, which had never frozen before. Ice on many of our "10,000" lakes was 30 to 40 inches thick.

During the last few months the Grand Rapids Kiwanis Club has heard about watershed management in northern Minnesota, and the local chapter of the Izaak Walton League was told about the current watershed research program at the Center and what some of the future plans include.

Soil Freezing in Plantations

During the winters of 1956-57 and 1957-58 soil freezing was examined under a 23-year-old red pine plantation and on adjacent aspen-brush area. At one time both areas supported a stand of brush and inferior hardwoods, but in 1937 a portion of the area was planted to red pine. Ten observations of type and depth of freezing were collected at each sampling date throughout both winters. The following table summarizes depth and occurrence of concrete frost during the early spring melt period:

	Red Pine Plantation		Aspen-brush area	
	Percent of occurrence	Average depth[1/]	Percent of occurrence	Average depth[1/]
		Inches		Inches
1957				
March 28	100	9.4	90	4.3
April 11	20	10+	30	3.8
April 17	20	5.0	0	0
1958				
March 28	100	10+	100	6.7
April 9	100	10+	20	3.5
April 23	20	4.5	0	0

1/ Average depth for those times that concrete frost occurred.

At each observation a small pit was dug to examine and identify the frost type, then frost depth was measured with a penetrometer. Depths over 10 inches were recorded as 10+.

The greatest average frost depth on any one sampling date in the red pine plantation was 10+ inches during both winters. In the adjacent aspen-brush stand it was 4.3 inches in 1957 and 6.7 inches in 1958.

Soil freezing was expected to be greater in the plantation since it had been disked prior to planting in 1937. Litter and organic matter accumulation averaged about 1 inch in the plantation as compared to $2\frac{1}{2}$ - 3 inches in the aspen-brush area. Total snow depth was greater in the aspen-brush area, but snow cover remained longer under the red pine.

Now before we give plantations in general a black eye, we would like to examine frost in planted areas that had not been subject to disking before planting.

--Roger R. Bay

Publications

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NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report April 1959

GENERAL

During the past six months arrangements were made for transfer of the watershed project at Kingston, Pa. to New Lisbon, N. J. and a more diversified program. The treated watersheds at the Fernow continued to provide interesting results, 32 snow courses were laid out in the Adirondacks for a study of snow accumulation and melt, and a survey of humus depth in virgin areas was completed.

KINGSTON RESEARCH CENTER

Completion of the Dilldown calibration and beginning of conversion of this watershed to conifer cover completed the initial effort in watershed research at this Center. Recent developments in cooperative research at Baltimore, Maryland, State College, Pennsylvania, and Newark, New Jersey have prompted us to consolidate supervision of these studies and move headquarters to a more central location at our New Lisbon Research Center in New Jersey.

Reigner will take over these larger responsibilities about May 1. Art Eschner, who has worked with Reigner for the past 4 years, has been transferred to our Elkins Center to join the Fernow watershedders.

Before closing the project at Kingston, two major manuscripts will be completed. The first is the results of the single-watershed calibration analysis for Dilldown which will be published as a Station Paper (the long version) and likely in the AGU Transactions (the short version). Also, to complete our publications of research progress and data from Dilldown, we have started work with the Department of Forests and Waters on Dilldown Report No. 4 which will contain 4 years results and data.

ELKINS RESEARCH CENTER

Treated Watersheds

In December, logging was finished on Watershed No. 3. Now the initial treatments are complete on the original "Fernow Five" gaged

watersheds. The four treatments are commercial clearcut, diameter limit (16"), extensive selection, and intensive selection; one watershed is a control and received no treatment.

Discharges for the first two watersheds cut were as follows:

	Streamflow					
	Clearcut 1/			Diameter-limit 2/		
	Predicted 3/	Measured	Increase	Predicted 3/	Measured	Increase
May - Oct. 1957	2.5	3.8	1.3	--	--	--
Nov. 1957 - Apr. 58	16.5	17.4	0.9	--	--	--
May 1958 - Nov. 58	13.0	17.5	4.5	14.9	15.8	0.9
			6.7			0.9

1/ Clearcutting started May 15, 1957, completed June 15, 1958.

2/ Diameter-limit cutting started June 23, 1958 and was completed August 22, 1958.

3/ If watershed had not been cut.

All increases shown in the above table were significant at the 5 percent level. The increase shown for the diameter-limit cut is small but most of the watershed had not been cut over in that part of the period which contributed most to streamflow.

Turbidities during storm periods are still high on the clearcut and diameter-limit watersheds with their loggers-choice skidroads. Turbidities are less than during logging; further measurements and analysis are required before the rate of recovery can be determined.

A small amount of turbidity during storm periods has been noted in the extensive selection watershed. A maximum value of 210 was measured during the logging operation. Road standard in this practice permit grades not exceeding 20 percent except for short stretches.

No measurable turbidity has been noted in the intensive selection watersheds. Standards here do not permit grades over 10 percent except for short stretches where steeper grades are unavailable. Special care is taken to locate the road away from stream channels and to prevent logging disturbance in or near the streambed.

A working plan was completed for the two openland watersheds recently established near Parsons.

Soil Moisture Measurement

Soil Moisture measurements to determine differences in soil-moisture loss on the clearcut and control watersheds were inconclusive. This may have been at least partly because we had a very wet summer and only a low degree of soil drying at any location. Highest values obtained were only a few percent above the lowest.

In October, 1958, a round of gravimetric sampling was made; six points on each of six plots in each of 3 watersheds were sampled. Taking of 6 samples per plot instead of the 2 previously taken apparently increased accuracy to the point where results are satisfactory. Analysis indicates that the standard error of the watershed mean (based on 36 measurements) was less than 1 percent for the second foot of soil depth.

The results of the neutron meter measurements that were taken were good. However, conclusions as to effects of treatments could not be drawn because of the small amount of sampling and the small range in moisture contents as discussed above.

Electronic Computer

In common with many others, we have been trying to see how the electronic computers could take over part of our analysis job. In line with this, daily streamflow for 5 watersheds for 7 years of record has been punched and run through the IBM 650. The punching was by IBM Service Bureau; the IBM 650 at Yale did the rest of the work. We now have sums and sums of squares and crossproducts to prepare regressions relating daily flow of each watershed to each of the others. Separate regressions can be computed for each month of the year, for the growing season, for the dormant season, and for the record as a whole. With these, predicted and daily flows can be plotted. These should be good for demonstration purpose and should facilitate study of the data to determine when and why we get the streamflow increases that show up in our more general analysis. We are also getting flow-duration curves by months and for the record as a whole for all watersheds.

Miscellaneous

George Hart and John Phillips left us in January. George transferred to Laconia while Phillips returned to the University of Wisconsin for graduate work in forestry. Art Eschner and family moved to Parsons in February. Art is working principally in watershed management research. Ken Reinhart spent the fall in Upper Darby taking the Station's "B Course" in statistics. Harry Yawney attended the statistical school in Laconia.

LACONIA RESEARCH CENTER

General

The vacancy in our watershed staff created by Dick Sartz' departure in August was filled by George Hart's transfer in January from the Fernow Experimental Forest in West Virginia. Since his arrival, George has become New Hampshire's number one outdoor enthusiast--seems he can't get enough of snow, snowshoeing, skating, and skiiing. Needless to say the local hospital and sporting goods stores are also happy George is here.

The building which was part of the property we acquired last fall for an administrative site has been remodeled as a residence. Ray Lavigne, our resident superintendent at Hubbard Brook, has moved his family into this dwelling.

Watershed activities have been drastically curtailed lately as Leonard, Hart, and Pierce are attending the Station's five-week Statistics Course A at Laconia. Lavigne and pinch-hitter James Clemons are maintaining our installations and gathering the snowballing winter data at Hubbard Brook.

A regularly scheduled monthly forestry seminar has been launched in Laconia. As the number of professional personnel and the type of activities has mushroomed at this Center in recent years a need was felt to provide a means of group communication of research problems among the staff members and other interested parties. One or two persons will be in charge of the hour long seminar and they will be free to discuss any forestry topic concerning items such as proposed studies, new techniques, or completed work. The seminar sessions will not be held during the summer field season.

Copies of the thesis on Landslides in the White Mountains of New Hampshire by Edward Flaccus (awarded a Ph.D from Duke University in October--now teaching botany at the Duluth Extension at the University of Minnesota) as reported in the last semi-annual are available on loan.

Watershed Activities

Unlike our past four winters we have not had a midwinter thaw. Several rains of about one inch or greater were completely absorbed in the snow pack with little or no resulting runoff. Our essentially frost-free forest soil now has a four-foot-thick blanket of snow bearing 10 inches of water. The Army surplus weasel we acquired last spring has proven its mettle this winter by bucking monstrous drifts and striding up slopes covered with non-supporting snow. With the weasel we are able to cut former transportation time in half and incidently reduce wear and tear on us aging watershedders.

The throughfall portion of our interception study which has been carried on this winter has yielded some interesting data. Our records to date show that our northern hardwood sawtimber stands intercept about 12% of the precipitation (as rain and snow) during the leafless period as compared to 26% of the precipitation (as rain) during the summer leaf period.

Our tests to date indicate there is no significant difference in precipitation catch between gages having tilted Alter windshields (tilted with the slope) and gages having non-tilted windshields (horizontal). Further tests will be conducted to determine if there is a need to shield our gages or if we are gaining much by tilting the gages.

Strip-Mine Revegetation

While at the Fernow last summer, Hart conducted a study of seedling survival of planted stock on strip-mine banks in central and western Pennsylvania. Although a detailed report of his findings will be published elsewhere, there are some interesting sidelights regarding soils information. The strip-mine banks were formed between 10 and 15 years ago and planted shortly thereafter with various tree species. The predominant surface material is blue and tan shale which decomposes rapidly. The soil content (material less than 2 mm.) on these banks is usually less than 50%. Red oak showed much better growth and slightly better survival on fine-textured soils.

Survival and height growth for Red Oak

	10-year height (feet)	Survival (percent)
Fine-textured soils (70% or greater silt and clay)	10.9	68
Coarse-textured soils (70% or less silt and clay)	7.4	57

Green and white ash appear to show this tendency to a lesser degree. Performance of conifers with respect to soil texture was highly variable with no apparent trends.

Soil acidity on most test areas was between pH 3.5 and 5.0. As these banks had pH's which fell within this same range 10 years ago, it is assumed that changes in soil reaction for this period on strip-mines in this region appear very slight. Tree survival on banks having pH's 3.2 and 3.3 was almost a complete failure for all species tested. Survival was much higher for most species on banks with pH's of 3.6 and above.

Miscellaneous

Pierce spoke to the Rotary Club at Laconia in January regarding watershed research in the White Mountains of New Hampshire. Leonard, Hart, and Pierce attended the National Conference on Agricultural Meteorology in New Haven, October 22, 1958. Pierce visited the Hopkins Memorial Experimental Forest to confer with Cunningham on prospects of improving the Williamstown watersheds. Hart and Pierce attended the Eastern Snow Conference in Cambridge, February 6.

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PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Semi-annual Report
Watershed Management Research

October 1, 1958 - March 31, 1959

WILLAMETTE RESEARCH CENTER

-- by Jack Rothacher

General

In the September 1958 issue of The Timberman there is a picture of a large load of logs being skidded off a steep slope with the caption "Don't waste money building mountain roads, doze a trail and skid'em out with a Le Tourneau Electric Arch" and at other times there has been a picture of a huge cat hauling logs down the middle of the stream. Maybe the logging industry is becoming more aware of watershed management but we sure must have overlooked the logging equipment manufacturers in our educational program!

Small Watershed Studies (FS-1-w5-2; FS-1-w7-6)

Finally we have gained some measure of control over the six year backlog of streamflow data that has been accumulating on the Andrews Experimental Forest. The first bits of information gleaned from these records show an average annual yield from 3 adjacent watersheds (149, 237, and 250 acres) of 59.84 inches. A recording rain gage in continuous operation near the lower end of these drainages caught an average of 92.06 inches of precipitation. Runoff was 65 percent of this.

We are experiencing considerable variation between the watersheds although they are adjacent drainages and the maximum extremities are only 1.7 miles apart. Part of the explanation may be in a very localized pattern of precipitation. A storage gage at 3000 feet elevation on the ridge at the top of Watershed #1 caught 20 percent less precipitation last year than the gage at the lower end of the drainage. The lower gage was in the lee of a ridge and it looks, at least locally, like precipitation may be greatest on the lee side of the ridge. Dr. Decker at Oregon State College has found similarly that on Marys Peak, highest point in the Oregon Coast range, the lee side gets about 75 inches of rainfall, while the windward side gets only about 40 inches. Of course this situation does not prevail over the main Cascade range as it is definitely wetter on the west (windward) side than the east. We are going to pursue this further with an intensified network of rain gages in the small watershed area. Dr. Decker is studying the same problem on a larger scale using a weather radar unit.

Following the method suggested by Kovner and Evans (Trans. AGU 1954) calculations have been made of the length of treatment period required for our small watersheds #2 and #3. To show significance of a 10 percent change from a 7-year calibration period will require a minimum of 2 years of record after treatment. But should we be satisfied with a 10 percent change in the total annual runoff in this country? That is almost 6 inches or ½ an acre foot per acre of drainage -- more water than the total from some of the "drier" country in a year.

The timber sale made to build 1.7 miles of road in Watershed #3 is now underway and the roads should be completed by the end of the present water year. This is steep but rather typical country and we hope this study will give us a better idea of how much damage is done by road construction and pinpoint the trouble spots that need more attention and study.

Interception (FS-1-w1-3)

In our interception study we found an interception of about 25 percent for summertime storms in old-growth Douglas-fir timber which contrasts to 34 percent reported from an earlier study in Washington. The difference is probably in the storm pattern. Analysed on a storm basis we found that:

$y = .818X - .043$ where X is rainfall in the open and y is an estimate of rainfall under old-growth Douglas-fir.

Records from one plot, operated on a year-long basis, showed an interception of 9.84 percent. It is obvious that interception is small during our "wet" season, and that is when we get over 80 percent of the precipitation.

A few sample stemflow gages installed last summer indicated that movement of water down stems is very minor in the summer. During the winter, however, when humidity stays high even between storms, the foliage and trunks of trees are almost constantly wet. We expect that measurements during the coming winter will show a significant amount of stemflow.

SISKIYOU-CASCADE RESEARCH CENTER

-- by H. G. Herring

Tractor Skid-Road Erosion (FS-1-w4-2)

The tractor skid road study, the initiation of which was reported last time, has not yet produced any positive results. Remeasurement of the profiles will not be made until the rainy season is over, and the data

from the sediment collecting drums is still incomplete. We have discovered however that the capacity of the drums is inadequate. In several instances the rate of runoff exceeded the discharge rate of the flow divider (about 0.057 cfs), causing the first drum to overflow. The second drum, which catches about 6 percent of the total runoff, frequently overflowed during a single storm. Apparently, we will have to modify our catchment devices or reduce the plot size.

Stream hydraulics

We, in cooperation with the Willamette Research Center, hoped to do some preliminary investigations into the hydraulic characteristics of typical Cascade streams. This was to be an initial step in a study of the problem of logging debris in stream channels, and we were particularly concerned with the high stage characteristics. Unfortunately (for us), streams in this area never went very high this year, and little was accomplished.

Experimental watershed access road

We have been allotted sufficient experimental forest road money to finance an access road into the stream gaging sites on the South Umpqua Experimental Forest. We flagged in the location last fall and the rangerdistrict has just about completed the design. The road should be completed this summer.

Miscellany

In October, the Center's Advisory Committee devoted the entire meeting to watershed management. It as a field meeting, but the afternoon was devoted to a discussion of the program. The committee expressed approval of the following program, with priority in the order listed:

1. Studies to determine methods of preserving soil and water values during and after logging. These will include studies of:

   a. Logging methods as they affect erosion

   b. Road building practices

   c. Problems associated with logging debris in stream channels

2. Basic studies of the hydrologic characteristics of important soils.

3. Development of methods to improve streamflow regulation and water yields.

4. Studies of the hydrologic characteristics of brushfields.

In December, the Center staff accompanied a group of industrial foresters on an inspection trip through some of their lands in the Rogue River drainage. Most of the problems pointed out to us were forest management problems, but watershed management did come in for some discussion.

Hallin and Herring attended meetings of the State Water Resources Board at which the Board's proposals for an integrated development of the water resources for the Umpqua and the Rogue Rivers were presented. Their program for the Umpqua was noncontroversial and was calmly received locally, but the Rogue program has generated a little heat. Heretofore, the use of Rogue River water for industrial purposes has been specifically prohibited by a state law. The Board recommended repeal of that proviso, and subject to such repeal, established industrial use as one of the beneficial uses. At this writing, however, the state legislature apparently is not going to authorize industrial use, which will throw a pretty large monkey wrench into the Board's program.

In March, Hallin accompanied the Oregon State College watershed management class on a field trip through part of this province. Our quite varied conditions and problems makes this area a good one for such field trips. (Herring, through the courtesy of the U. S. Navy, was spending two weeks examining the ultimate source area for most of the water supplies of the West, at the time of this trip.)

BLUE MOUNTAIN RESEARCH CENTER

-- by Dan Bishop

Scab Ridge Study (FS-1-w1-4)

During the past fall and winter our installation of four runoff plots on shallow soil underlain with unweathered basalt has proved to be leaky. Sub-surface flow seeped under the concrete plot curbings even though they were laid on bedrock. We are presently trying to seal the leaks with bentonite.

Soil Moisture Regime in Lodgepole Stands (FS-1-w1-6)

We will begin this spring to take soil moisture samples in three lodgepole stands of moderate densities. Our first purpose will be to describe the seasonal march of soil moisture at three depths within the lodgepole stands. As a secondary feature of the study, we will examine the rooting habit of lodgepole. Also, we will measure net stand rainfall and gross rainfall-intensity to examine their effects upon soil moisture. After a growing season's measurement of soil moisture in the lodgepole stands, we plan to cut one of the two plots in each stand to see how the opened plots differ in soil moisture regime from their stocked counterparts. This is an influence study which should not only serve to tell us something about the efficiency of lodgepole as a watershed cover, but should be useful silviculturally, as lodgepole becomes a managed species.

Alpine Snowfield Research and Management (Extra-curricular)

While taking a 4-day ski-trip into the high alpine country of the Wallowas, this winter, I was particularly impressed with the expanse of open snowfields which might be susceptible to treatments either to speed or slow snowmelt. Our future research might consider the use of chemicals to retard or control snowmelt rate on such areas.

The tremendous cornice development on the high ridges also appears to offer a possibility of manipulating snowmelt. Frequently the cornices overlook deep canyons which tend to protect their snow catch from much of the day's direct radiation. Would it not be possible to avalanche large volumes of snow into the canyons from the steep upper slopes, and thereby enhance snow storage and further treatment to retard melt?

This trip emphasized to me the importance of research on the manipulation of high alpine snows. Access to such areas is often difficult, but results could be gratifying. Perhaps we will see the day when alpine slopes and ridges are treated with helicopter for modifying high elevation snow storage.

MID-COLUMBIA RESEARCH CENTER

-- by Dave Wooldridge

Entiat Pilot Watersheds

Our inquiries about concrete block construction of cut-off walls for weirs did not bring forth any helpful suggestions, but we are going to try this type of installation during the coming summer anyway. Only materials available at the gaging site are water and wood. About 40,000 pounds of concrete blocks, sand, gravel, cement, reinforcing steel and lumber must be packed over a mile-long trail.

We are planning to use a 120 degree V-notch weir designed for a 3 feet maximum head. Very little information is available on maximum flow rates but we expect discharges in excess of 2 feet head only on rare occasions. Elevations of the watersheds range from about 2,500 feet on the lower end to over 7,000 feet in a distance of 2 1/2 miles.

We are not sure what we are getting into, but by this time next year we will know considerably more about concrete block construction problems.

Sediment Production Study (FS-1-w4-2)

The last visit to our three small sediment study watersheds in Mission Creek indicates the choice of area was good; i.e., it is poorly protected from erosion. Through the snow and ice considerable sediment could be seen. Snow will soon leave the area, so it will be accessible without an 8-mile snowshoe trip. We will then check winter sediment

accumulations and prepare for summer showers and more sediment.

Results of Fertilization (FS-1-w6-1

Benefits of fertilizer application were shown in tests on two severely depleted Swauk sandstone sites in Mission Creek watershed near Wenatchee, Washington. Significantly increased growth of native grasses resulted from application of nitrogen, phosphorus, and potassium in various combinations. A nonorganic wetting agent(Aqua-GRO) was also tested. Best response in both study areas was obtained with $N_3P_2K_2$. Air-dry yields (pounds per acre) of plant cover used to evaluate effects of fertilizer treatment were as follows:

Treatment	Area 1[1/]	Area 2[2/]
$N_3P_2K_2$	610	1950
N_3	[3/]260	1770
N_2P_1	450	1480
$N_1P_1K_1$	510	1350
$N_1P_1K_1$ + wetting agent	490	1330
None (control)	130	920

1/ First year after fertilization.

2/ Second year after fertilization (No clippings taken previously.)

3/ Not significantly greater than production on control plots. All other yields from fertilized areas were significantly greater than yields from control plots.

BULL RUN PROJECT

-- by Nedavia Bethlahmy

Erosion from Logged Lands (FS-1-w5-2)

Erosion from logged lands in the Bull Run watershed continues to be one of our primary concerns. To this date, the Forest Service has refrained from selling any timber within the watershed. But logging is not prohibited by law, and since the timber is over-mature, and our social and economic environment has been changing rapidly, it is entirely possible that the logger's axe will some day be wielded in the Bull Run Reserve. Unfortunately, in this area the effect of logging

on soil erosion is far from negligible. Partial analysis of our data indicates that the initial rate of soil movement immediately following clearcutting exceeds 100 tons per acre per winter season. As a result of clearcutting operations for a new dam, the suspended load in Portland water has reached the nuisance point. For example, the Forest Service cartographic section has used in the past ordinary tap water for film processing; now they are forced to filter the water. Moreover, as a direct result of the logging operations, Portland has had to increase the chlorine content of the water. To the dismay of pisciculturists, the chlorine level is lethal for goldfish.

This winter, additional erosion plots were installed in the area. But we also want to locate plots where logging will start and end during the summer months. Such plots will enable us to measure the effects of a full winter.

The following incident may interest our practical watershed managers. The Forest Service is now building a new access road in the vicinity of the Bull Run river. After a heavy rainstorm passed over the area, all logging operations were suspended to forestall any movement of mud into the river.

Contrast these civic and administrative troubles with the fact that Bull Run water issuing from undisturbed areas has 0 to 30 ppm of sediment! It is evident that the solution to the Bull Run area's future erosion troubles brooks no delay.

Road-bank Seeding (FS-1-w6-3)

How to stabilize road banks is another important problem in this area. A study plan has been prepared to find answers to the following questions: What grass mixtures can be used to stabilize road banks in the Bull Run area? What constitutes a good rate of fertilization? Is fall or spring seeding preferable? The experiment has been geared to mesh with the plans of a ranger district project, and will be installed in the early spring.

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SEMIANNUAL REPORT - October 1, 1958 through March 31, 1959
Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

GENERAL

A major undertaking during the past 6 months has been the initiation of a new watershed research program in Wyoming. Herbert W. Berndt, formerly with our Fort Collins unit, has moved to Laramie to take over the job. He tells about it in the "Laramie" section of the report (RM-10).

Another extension in our program has been in New Mexico. George Coltharp moved to Albuquerque in November to get the ball rolling on new watershed management research in the Sangre de Cristo Mountains (RM-2).

Bert Goodell, of Fraser fame, has transferred from the Fort Collins unit to the Watershed Division. He will be dividing his time between fundamental research (mostly in solar radiation) and providing research guidance for graduate students in watershed management at Colorado State University.

Still another change in the Division has been Harry Brown's move from the Grand Junction unit to a new position as assistant to Division Chief Marvin Hoover. Harry's replacement at Grand Junction is Bob Thompson, formerly at Albuquerque.

Watershed management research in the Sangre de Cristos

Watershed management research on forested watersheds in the Sangre de Cristo Range of northern New Mexico was initiated during the Fall of 1958. Future basic research will be concerned with factors affecting the accumulation and disposition of the snowpack and allied factors influencing the water regime of these high altitude watersheds. The study area includes the ponderosa pine, spruce-fir, and aspen vegetation types which range from 8500-12,000+ feet in elevation.

The initial phase of the work, which is currently underway, entails a reconnaissance study of snowpack conditions on these high altitude watersheds. This preliminary study is serving a dual purpose, i.e. we are getting some necessary data on snowpack accumulation and disposition as well as becoming familiar with the general study area. Several interesting observations have been noted during the course of the reconnaissance study. Of particular interest and posing suitable problems for future investigation are the following:

1. There is considerable wind movement in the snowpack zone. This poses problems in sampling the snowpack since the wind rearranges the snow after initial deposition. Snow intercepted by conifers rarely remains on the crowns as the wind blows it "hither and yon." Wind movement also fosters what might be termed positive interception, i.e. snow swept off open areas accumulates in the surrounding timber forming deep drifts.

2. Snow rapidly disappears on steep south slopes after each snowfall. The disposition of snow on south slopes requires detailed investigation in order to ascertain what part moisture received on these slopes contributes to water yield.

3. Soils are predominantly frozen on open and aspen-covered south slopes. Although the frozen soil extends to a depth of only 4-5 inches it is enough to prevent movement of snowmelt water into the profile. Melt water apparently moves downslope through the humus and upper 1 inch of soil and may be exposed to higher evaporative loss than if absorbed at the point of melt.

4. Rime ice is a rather frequent occurrence at the higher elevations (10,000 - 12,000 ft.). The ice builds up several inches thick on the windward side of trees and objects exposed to the wind. These accumulations of ice would appear to make some contribution to the winter precipitation recieved on the area but we have not attempted to evaluate this contribution as yet. Rime ice has also been observed on pinyon, juniper and ponderosa pine trees at the lower elevations,

since this Center was established. If anyone has had occasion to measure quantitatively such phenomena or knows of any work which has been undertaken on it we would appreciate your comments.

This winter's study has been hampered to a great extent by the extremely light snowpack in the Sangre de Cristos. The snowpack is about 1/3 of normal and it is exceedingly difficult to detect differences in snowpack behavior attributable to various site factors.

A project analysis for watershed management research on the forested watersheds of the Sangre de Cristos is also underway.

G. B. Coltharp

Evaluation of soil and water conservation practices underway

Surface runoff plots are being installed on public domain land (in cooperation with the Bureau of Land Management) to evaluate the effects of soil ripping (Jayhawker), soil pitting (Calkins pitter) and sagebrush chaining on surface runoff, erosion and residual vegetation.

In addition to evaluating the effects of these soil and vegetation treatments on range and watershed conditions, we expect to obtain information on the types of treatments needed to effect rehabilitation of one of the San Luis experimental watersheds.

Four comparisons will be made in conjunction with the soil treatment. These are the check or control, soil treatment, soil treatment plus seeding to alkali sacaton (native grass spp.) and soil treatment plus seeding to chamiza (a native browse spp.). Superimposed on soil and vegetation treatments will be animal treatments (opened and closed to livestock and rabbits).

Evaluation of soil pitting (Calkins pitter) on several watersheds in the cornfield wash (USGS) indicates this practice reduces surface runoff the first and second year and some effect may carry over beyond this period. We believe soil pitting and ripping should be used as a means for establishing a permanent cover of vegetation for continued reduction of surface runoff and erosion.

Soil ripping (chiseling) appears the best practice in the Rio Puerco and adjacent drainages. Some evaluation of this type of treatment is needed. We also need to know whether the beneficial effects of this soil treatment can be prolonged through establishment of a stand of perennial grass and/or a cover of browse. Whether this type of soil treatment contributes toward successful establishment of seeded vegetation is also important.

Soil ripping with a Jayhawker loosens the soil to a depth of 32 to 40 inches on sandy loam soils, even under moderately compact

subsoils. The ripper was effective to a depth of 26" to 28" on shallow soils (less than 6") overlaying shale parent material. Limited tests indicate that complete soil sealing under extremely poor soil conditions will probably not occur until several years after treatment, even without introduction of vegetation. Application of 9.5 inches in one hour failed to produce surface runoff on an individual test. The ripped soil was estimated to have lost about half of its original effectiveness. This amount of water application is equal to the high intensity rainfall received over a 2 year period. Introduction of vegetation with a good root system and protection against rainfall impact should provide the conditions needed for continued reduction in runoff and erosion.

E. J. Dortignac

FLAGSTAFF

Some instrumentation adaptations used on the Beaver Creek Watershed Project

Some of the adaptations of methods being used to measure precipitation and relative humidity may be of general interest, and are described below:

1. Standard rain gage funnels are cut out to avoid hail bouncing out and snow piling up. Gages are "charged" with transformer oil (less greasy than motor oil and works well) to prevent evaporation. Calcium chloride is combined with transformer oil during the winter to avoid freezing. Gages are weighed with Chatillon hide scales (60 pound capacity) to measure amount of precipitation.

2. Recording rain gages are "charged" with about two inches of water (without oil) yearlong. Evaporation rates from the weighing bucket are high enough to record a separate pen line for each day of the week. This procedure permits ready identification of time of the particular day when precipitation occurred.

3. Hygrothermographs are elevated and kept level in weather shelters by using a $\frac{1}{2}$-inch angle iron frame cut to fit the instrument. The angle iron is notched prior to bending, and a spot weld used to hold the two frame ends. The frame is elevated by $\frac{1}{2}$ x 6 inch threaded rods with nuts and washers for use in balancing.

E. F. Aldon

Disposition of precipitation in the Utah juniper type

Precipitation.--Total precipitation from April 15, 1958, to March 20, 1959, was 14.20 inches. The distribution of this precipitation has beenvery irregular, approximately 4.00 inches from April 15 to September 10 (this period normally includes the summer rainy season), and 10.20 inches during the remainder of the period. From

May to July there were 70 consecutive days with no rain; from December to January there were 45 consecutive days with no rain. Of 31 recorded storms, a single storm in September accounted for 25% of the total precipitation, and all storms in September accounted for 45% of total precipitation.

Interception.--Net interception varied from 2% of total precipitation in a juniper plot of light density to 21% on a plot of heavy density. Total stemflow varied from 0.03 inches on a plot of light density to 0.56 inches on a plot of heavy density.

Soil Moisture.--Winter recharge has been confined mostly to the upper 18 inches of soil. Recharge did not reach field capacity even in this comparatively shallow depth.

Surface Runoff.--Surface runoff for the year for an average of eight, 2 ft. x 3 ft. runoff plots, varied as follows for three densities of juniper: light density, 1.04 inches; medium density, 0.60 inches; heavy density, 0.19 inches.

Soils.--Soils under study are derived from basalt, with a caliche layer usually separating parent rock from the montmorillonitic type clay soil above. There is little profile differentiation: percent clay grades from 63 to 72 at 48 inches; pH grades from 7.4 to 8.2 at 48 inches; and color grades from 7.5YR 3/2 to 5YR 4/3 at 48 inches.

Roots.--Approximately twenty soil cores of 1.0 inches diameter were collected from four plots of medium and heavy density of juniper. The cores were 48 inches long and divided into 6 inch intervals. The 6 inch samples (five per plot for each depth interval) were grouped by plot and washed over a 2 mm screen, separating stones and roots from soil. After air drying, the roots were floated free of stones, oven dried and weighed to 0.001 gm. The ratios of oven dry weight of roots and soil in relation to depth of soil were as follows:

Depth of Soil (inches)	6	12	18	24	30	36	48	60	90
$\frac{\text{Wt. OD Roots}}{\text{Wt. OD Soil}}$	3.0	2.4	1.6	1.2	0.8	0.6	0.4	0.2	0.1

C. M. Skau

FORT COLLINS

The Fool Creek experiment

1958 was the third year of water yield measurements since timber was harvested on 278 acres of the 714-acre Fool Creek watershed. An increase in water yield continues to result from this cutting experiment. A covariance analysis using the years 1956, 1957,

and 1958 reveals an average increase in yield of 3.33 area-inches. Most of the increase in water yield has occurred in the period before July 1 for each of the 3 years.

Measurements of sediment in the stilling pond at the Lower Fool Creek gage, has not revealed any serious erosion. For the three post-treatment years there has been only 1.8, 3.4, and 2.1 cubic feet of sediment per acre of watershed deposited in the pond.

Weather at Fraser Experimental Forest Headquarters

Nineteen years of weather records, taken at Fraser Experimental Forest Headquarters, have been analyzed recently. There have been several periods, particularly in the winter, when weather records were not taken. Therefore, the following figures should be regarded only as indications of weather conditions.

Air Temperature: The mean monthly temperature is 32° F. February has had the coldest monthly mean of 10° F. The highest recorded temperature is 83° F; the coldest is 42° F. below zero. The temperature dips below 32° F on 320 days a year.

Soil Temperature: The soil temperature has been taken at a depth of 3.5 feet. The lowest recorded winter soil temperature was 31° F. and the highest summer recording was 52° F.

Precipitation: For four consecutive years, the average yearly precipitation was 23.5 inches. It is interesting to note that there was an annual average of 1.61 inches more precipitation at the Fraser Experimental Forest headquarters than in the town of Fraser located 5 miles away and 440 feet lower, on the floor of the Middle Park Valley.

G. B. Lloyd

Weather instruments at windy sites

For the past several years, precipitation records taken in the alpine area of Colorado have been spotty because of the difficulty in keeping snow out of the clock of the recording rain and snow gage (weather bureau type). Snow filtered through the joint where the funnel unit fits over the main cylinder as well as through the joint between this cylinder and the base. During periods of high winds and heavy snow transport, enough snow accumulated around the clock to stop it in spite of a canvas cover wired around the gage.

During February of this year, the precipitation recorder was slipped into a surplus military barrack's bag made of rubber coated canvas. When wired at the top, this bag covered all cracks and joints in the case of the precipitation gage and seems to have solved the problem of keeping the clock free of snow.

At the same site, attempts were made to keep snow out of a standard weather bureau instrument shelter by lining it with furnace filters on three sides. This has not been satisfactory at all. Snow still sifts into the shelter and covers the temperature and humidity elements of the hygrothermograph and accumulates on the maximum and minimum thermometers. Does anyone know anything about the successful use of double-louvered shelters or other special devices to keep instruments free of snow at windy sites and still permit reliable records to be taken? If so, I would appreciate hearing about them.

M. Martinelli

German publication reviewed

"The influence of forests and clear-cut areas on streamflow, the hydrologic process and erosion." ("Der Einfluss des Waldes und des Kahlschlages auf den Abflussvorgang, den Wasserhaushalt und den Bodenabtrag.") Results of the first 5 years of a forest-hydrological study in the Oberharz (1948-1953), and one separate appendix of tables with 105 pages. By Delfs, J. et al. 1958. M. and H. Schaper, Hannover, Germany. 223 pages.

A REVIEW

The German Forest Service as well as the German public grew quite concerned about the vast clear-cut areas in their forests, scars of World War II and the post war years. Heavy erosion damages were expected that would permanently endanger the growth of trees, so vitally important to the livelihood of the German people. Therefore, the Forest Service of the State of Lower Saxony initiated an investigation to study runoff and erosion.

Watersheds were selected in the Harz Mountains of Northern Germany. The elevation of the chosen watersheds range between 1,700 and 2,500 feet. The parent material consists of Under Devonian Kahleberg sandstone. The climate is humid with a yearly precipitation of 53.11 inches (40 years mean) and a mean relative humidity of 84 percent. The mean annual temperature is 42.5° F. The growing season lasts 187 days. Snow covers the ground intermittently from November to April inclusive. Winter and summer precipitation have a relationship of 51:49.

In 1949 two adjacent watersheds with roughly corresponding characterisitics were selected. The Wintertal drainage, an area of 215 acres, is covered with pure Norway spruce (Picea abies). It received the normal selective cuttings for stand improvement. The stand density ranges from 1.0 to 0.6. The Lange Bramke watershed, 186 acres in size, was formerly stocked with Norway spruce and clear cut in 1948. Both watersheds possess live streams. The Wintertal Creek yielded an average daily flow of 1.97 c.f.s./sq.mi. compared with 2.05 c.f.s./sq. mi. of the Lange Bramke Creek. The difference

is so small that it could be well within the measuring error. Unfortunately, no precalibration was established. A comparison of the instantaneous maximum flow of the watersheds leads to a more pronounced discrepancy (22 percent). Lange Bramke 25.48 c.f.s./sq. mi.; Wintertal 19.89 c.f.s./sq. mi.

During 1951 and 1952 three smaller forested watersheds (100 percent Norway spruce) were added for replication.

To study the influence of a forest canopy on precipitation, interception was measured under Norway spruce stands of different age classes. Rainfall pans of an extra large size were designed (5 m x 0.20 m) to catch precipitation. Months with abundant precipitation that occurs as long-duration rainfall with low intensities show small interception values. High values are derived in months of low precipitation with short-duration cloudburst storms. The interception of snow was smaller than of rain. The study was executed yearlong for 4½ years. Since proper sampling techniques were not applied, the data should be considered only indices.

In connection with the interception study, stemflow from 15, 30, 60, and 80-year-old Norway spruce trees was investigated. A recording rain gage combined with the instrumentation demonstrated the influence of rainfall intensity and duration of stemflow. Stemflow increases with increasing precipitation and with increasing tree diameter. According to age of tree, wind direction and velocity, and rainfall pattern, it started between 2 and 10 hours after the rainfall had ceased. Highest volumes occurred under long-duration low intensity storms.

To study the role of the surface soil conditions influencing the erosion process, plots 3m x 1m were framed with sheet metal bands which were set 15 cm into the ground. A plot in mineral soil yielded in 1 year 8.01 tons/acre of sediment, after establishment of vegetation (Aira flexuosa) only 0.15 ton/acre.

A logging skid trail, 910 feet long, was gaged for gully and sheet erosion investigations. The trail had developed into a gully with a maximum depth of 2.5 feet. The average bed slope was 27 percent, the drainage area 0.74 acre. From 1949 to 1955 the erosion of coarse material decreased from 180 cu. ft. to zero. By that time native vegetation covered nearly all of the drainage area and the skid trail.

The suspended sediment load of the creeks was measured by bottles that were placed above the weir and protected by a wire cage. The bottle inlets closed automatically after filling. To measure the load of different stream stages, the containers were installed at various levels. The effect of the wire cages was not investigated. During the first two study years the suspended sediment load of the untreated watershed (Wintertal) amounted only to 29 percent of that

of the clear-cut watershed (Lange Bramke). Larger differences still existed in bed load and coarse sediment transport. In 1949, 61.1 cu. ft. were deposited at the gaging station of the clear-cut drainage against 2.5 cu. ft. from the forested area. Beginning in 1953 with the natural regrowth of the vegetation, the treated watershed contributed no coarse sediment.

This German publication contains detailed descriptions of climate, topography, geology, soils, vegetation, and hydrological aspects of the experimental watersheds. Since precalibration was not executed, the results of this study do not permit conclusions about the behavior of a clear-cut watershed with respect to an untreated watershed. Statistical analyses have not been applied to show the significance of the data. Yet, it is demonstrated that Germany has no serious erosion problem as long as the natural rehabilitation process of the vegetation takes place. The study is a valuable contribution to our knowledge about watersheds.

B. H. Heede

GRAND JUNCTION

Things at Grand Junction are at the breath-holding stage, with two major studies on the verge of producing long-awaited results. In neither study are we predicting what the results will be -- it looks as if we will have to wait for the next semi-annual report to present these.

Three years' measurements of water use by aspen, spruce, and grassland have been completed on Black Mesa, and we are in the midst of final analysis.

At Badger Wash, down in the salt desert shrub country, five years have gone by since livestock were first excluded from four of our eight experimental watersheds. We have been using the Rocky Mountain Infiltrometer to measure the effects of this treatment on infiltration and erosion. Forty-eight pairs of infiltrometer runs were made at the start of treatment in 1953-54. Forty-eight more runs were made in 1958. The most notable thing we can report at the present time is that the entire infiltration data are being set up for machine computation and analysis. Using the Burroughs E 101 digital computer and assorted IBM card-punching machines we hope to accomplish a winter's work in a week. The help of Colorado State University's computing center has been enlisted for this job.

Bob Thompson
Harry Brown

LARAMIE

Watershed and related range research in Wyoming is a recent addition. At this writing, the first full-time watershed researcher assigned to the unit is completing the second week of his assignment. A second man is anticipated in early summer.

This year a study will begin on three high elevation sagebrush watersheds. There are 20 million acres of sagebrush in Wyoming, some of it with a good understory of grasses and forbs. Research has shown that removal of sagebrush by spraying is possible and economically justifiable through increased herbage production. Interest developed in this program has resulted in the eradication of sagebrush from more than 50,000 acres. This successful climax to one important field of research has developed a new set of problems to study.

Evaluation of the impact of sagebrush eradication on the watershed will be the objective of this first project. The effects of complete and partial removal of sagebrush on snow pack, snowmelt, runoff, sedimentation and storm runoff will be studied. Concomitantly, the effects of sagebrush removal on forage habits of big game and the management of livestock on treated areas will be under study.

During last summer and fall, watersheds 60, 80, and 110 acres in size were selected and stream gage construction was carried to a point where it will be possible to make 1959 the first year of the calibration period. Completion of the installations, routine observations, soil and vegetation inventories and completion of a project analysis will keep us occupied this year.

H. W. Berndt

RAPID CITY

Soil moisture under thinned and unthinned ponderosa pine.

We now have a full year's record in our plot study of soil moisture under thinned and unthinned ponderosa pine. Three adjacent 120 x 150 foot plots were located in a dense 65-70 year old stand. One was clear-cut and has been kept bare of all vegetation, a second was thinned to about 10 x 10 foot spacing leaving 80 square feet per acre basal area, and the third was left undisturbed. Basal area on the undisturbed plot is 171 square feet per acre.

A total of 22.77 inches of precipitation was measured in the open between September 30, 1957 and October 1, 1958. Throughfall precipitation was 19.76 inches on the thinned plot and 17.03 inches on the unthinned plot, or 87 and 75 percent of gross precipitation, respectively. Thus the thinned pine with a canopy density of about 35 percent intercepted 3.01 inches or 13 percent of precipitation

while the unthinned pine intercepted 5.74 inches or 25 percent of total precipitation.

Stemflow was 0.04 inch for the year on the thinned plot and about twice this amount on the unthinned plot. Measurements were made on 10 trees in each plot. Stemflow on individual trees ranged up to seven gallons in a week when 2½ inches of rain fell. Dominant and codominant trees on the unthinned plot produced as much or more stemflow than comparable size trees on the thinned plot.

Surface runoff was measured on two mil-acre plots in each treatment beginning July 7. To October 1, 0.16, 0.31, and 0.19 inch of runoff was measured from the clear-cut, thinned, and unthinned plots, respectively. These amounts were 2.6, 6.9, and 5.1 percent of precipitation reaching the ground in the period.

Moisture penetrated to three inches depth between the middle and end of March on all three plots. By mid-April moisture had penetrated to six feet on the clear-cut plot. Moisture penetrated more slowly on the thinned plot--not reaching six feet till near mid-July. The deepest that moisture penetrated on the unthinned plot was four feet--also about mid-July.

There was enough precipitation to maintain soil moisture till about the end of July. But during an unusually hot dry spell that started about August 1 moisture withdrawal was rapid from both the thinned and unthinned plots. The withdrawal was more rapid and to a lower moisture content on the unthinned than on the thinned plot. The only pronounced moisture loss from the clear-cut plot was by evaporation from the top foot of soil.

During the coming field season soil core samples will be collected and analyzed for bulk density, and field capacity and wilting point moisture contents. Additional soil moisture samples will be taken. Final results, at the end of two years of observation, will be expressed in inches of available moisture.

Surface runoff from grazed bluegrass range

A 16 x 16 foot runoff plot was installed on a grazed Kentucky bluegrass streambottom site on June 27, 1958. Between June 27 and October 1, 5.78 inches of rain fell. Total runoff during the interval was 0.31 inches or 5 percent of rainfall. However, 0.27 inch of the total 0.31 inch of runoff came from one high intensity storm on September 10. Total rainfall depth was 0.65 inch, all of it falling in a 12-minute period. Maximum 5-minute rainfall was 0.40 inch--an intensity of 4.80 inches per hour. Runoff was 42 percent of rainfall in this one storm.

Water temperature measurements

Water temperatures were taken periodically between June 17 and September 5 at the upper and lower end of a 1/4-mile stretch of stream channel rerouted and straightened in the process of road building. Stream shading vegetation was destroyed and the grading left few pools. The stream is exposed to full sunlight. This channel treatment is not uncommon in constructing roads in the narrow valley bottoms of the Black Hills. The stream on which the temperature measurements were taken was reputedly one of the better trout streams in the Black Hills at one time, but now it is comparatively poor.

Water temperatures at the downstream end of the stretch ranged from zero to 3° F. higher and averaged 0.9° F. higher than at the upstream end. The averages were 68.6° F. and 67.7° F. Individual measurements ranged from 58 to 76° F. at both locations. Although there was a small increase in temperature downstream the maximum temperatures were high enough to make both locations marginal habitat for most trout species.

Howard Orr

TEMPE

Streamflow and precipitation from the Castle Creek watersheds

The Castle Creek watersheds have been characterized by wide variations in precipitation and streamflow in the three years since their installation. These watersheds are located at an elevation of 8,000 ft. in the ponderosa pine type. Commercial timber grosses 11,000 board ft. per acre. Watersheds are 890 and 1080 acres in size.

During the three years of calibration very little runoff occurred the first year, the second year most of the runoff resulted from summer precipitation and the third year most of the runoff can be attributed to snow melt. Distribution of streamflow and precipitation by months has been as follows:

Precipitation and Streamflow -
Castle Creek Watersheds
(in inches)

Month	1955-56 Ppt.	1955-56 Runoff East Fork	1955-56 Runoff West Fork	1956-57 Ppt.	1956-57 Runoff East Fork	1956-57 Runoff West Fork	1957-58 Ppt.	1957-58 Runoff East Fork	1957-58 Runoff West Fork
Oct.	1.15	0	0	1.24	0	0	4.06	.096	.026
Nov.	.56	0	0	0	0	0	1.49	.147	.080
Dec.	1.18	0	0	.34	0	0	.59	.010	.010
Jan.	1.76	0	0	4.13	.005	.001	.92	.001	.006
Feb.	2.19	0	0	1.36	.037	.005	3.48	.244	.232
Mar.	0	.058	.018	2.13	.056	.021	5.89	1.657	1.956
Apr.	.82	.005	.007	1.51	.012	.012	2.47	5.565	3.532
May	.69	0	.004	2.14	.039	.016	.57	.149	.041
June	1.31	0	0	1.89	0	.002	1.83	.002	.001
July	2.53	0	0	5.61	.161	.187	2.04	0	0
Aug.	2.03	0	0	9.51	1.169	1.166	5.27	.004	.001
Sept.	.28	0	0	.35	.361	.101	6.47	.102	.050
Total	14.50	0.063	0.029	30.21	1.840	1.511	35.08	7.977	5.935

Moist site clearing on the north fork of Workman Creek

Clearing of 80 acres of moist site white and Douglas fir in the bottom of the 248 acre north fork of Workman Creek is now nearly completed. Removal of saw timber, clearing of non-commercial material, and slash piling were completed November 1, 1958. During the last week of October and the first week of November, the area between the slash piles was seeded to a mixture of 40% Kentucky bluegrass, 40% slender wheatgrass, and 20% orchard grass with a cyclone hand seeder at the rate of 6 2/3 pounds per acre. After seed coverage an additional 3 1/3 pounds per acre of the seeding mixture was broadcast over the area.

To remove the fire danger during the summer fire season, slash was burned during the winter when snow was on the ground. Slash burning was completed on March 7, 1959. In general, fuels larger than about 4 inches d.b.h. were not consumed. Seeding into the ash of the slash piles will be completed in June.

Crest gages used for reconnaissance survey

As part of a reconnaissance survey of streamflow relations in the pine-fir areas of Arizona, crest gages were installed at culvert openings on several watersheds. Crest gages construction was adapted from that described by Floyd J. Doran in Civil Engineering, 1942, page 103. As constructed, these gages consist of a 3/4-inch pipe with inlet holes, a bolt across the pipe below the water line and a cap to prevent precipitation

from entering the pipe. A piece of 3/8-inch reinforcing steel painted with yellow dextrin is inserted inside the pipe to rest on the bolt. The dextrin dissolves after a few minutes contact with water. Resulting high water marks have been sharp and easily identified.

L. R. Rich

Comparative evapo-transpiration from Tamarisk and Bermudagrass

Analysis of data collected last summer by the infrared gas analyzer method showed that evapo-transpiration from mixed tamarisk-Bermudagrass plots increased nearly linearly with amount of tamarisk.

Field operations during 1958 suggested several minor modifications of the apparatus. New tents have been constructed of 1-mil Mylar, which is stronger, more transparent and more stable than polyethylene. A shorter optical pathway was made for the infrared gas analyzer to improve the calibration curve, and the meter was rescaled to read directly in milligrams of water per liter of air. These modifications simplify record taking and computation.

J. P. Decker

Germination and stem sprouting of tamarisk

Germination tests with tamarisk seed have been continued through the winter at less frequent intervals. Tamarisk seed collected in the late summer and fall of 1958 and stored at room temperatures ranged from 0 to 5% viability in February. In contrast, lots collected in the spring and early summer of 1958 had lost all their viability by 6 to 12 weeks. This pattern of prolonged viability of seed collected in the latter part of the season verifies the results obtained with 1957 seed. Tamarisk seed lots collected in August and September 1957 and stored at 40° F. were still giving as high germination as 75% in February 1959.

Additional cuttings of tamarisk stems have shown that no sprouts occur from those collected in the latter part of November and December. All cuttings collected late in January produced some sprouts.

J. S. Horton

Controlled burning of chaparral

Broadcast burning under prescribed "low hazard" conditions is being studied as a possible tool for controlling, or suppressing shrub species on sites where this practice is found to be desirable for range or watershed management purposes.

At 1:25 p.m. on October 16, one 12 x 4 chain Block, smashed at 3 intensities in May, was ignited. Rapid ignition along the edges and through the center of the plot was affected by men carrying torches. At the time of firing, wind was gusty, from 0 to 7 mph. Air temperature and relative humidity were 81° F. and 14% respectively, and fuel moisture content of the heavier smashed stems was 5 percent.

Observations on fire behavior showed that: (1) Fire did not build up enough energy to approach so-called "fire storm" proportions; and there was no tendency for fire to be drawn to the center of the plot by convection forces; (2) Fuel consumption for the whole block was poor. The fire seldom spread beyond the ignited bush in the untreated areas; but did spread in the few cases where there was good continuity of smashed plants; (3) No difficulty was encountered in confining the fire within the lines.

Conclusions drawn from observations made during and after the fire were: (1) Lack of continuity of smashed bushes prevented fire from making desired spread across the plot; (2) Density of brush, which averaged 34% shrub crown cover but varied from 17% to 57% on the 2 x 2 chain subplots, may have been too light to produce proper burning despite prior smashing and drying of fuel. Low stature of brush, which averaged less than 40 inches before smashing, was also a determining factor.

Plans for continuing this study include: (1) Burning of one more block in April 1959 but with all bushes smashed to obtain maximum continuity, compaction, and flammability of fuel; (2) Continue investigation of mechanical compaction and drying, and observe the effects of herbicides and other chemicals in reducing moisture content of brush; (3) Extension of burning trials into chaparral areas with greater density and stature and situated on somewhat steeper slopes.

G. E. Glendening

Herbage production on a burned chaparral range

Three growing seasons after a June fire, production for all classes of vegetation on the Mingus Mountain area was still increasing rapidly. Brush species, primarily turbinella oak, composed 76% of the 1958 annual production, grass 5%, and forbs 19%. Seeded grasses, weeping lovegrass and crested wheatgrass, were most successful at the upper edge of the chaparral type above 5,500 feet. However, for the entire burned chaparral area, native grasses outproduced the introduced grasses. During the third growing season, an evergreen perennial forb, Penstemon palmeri, became very abundant at the middle and upper elevations, and was largely responsible for the increased yield of forbs.

Ground cover is also increasing rapidly as shown by the tabulation below. Shrubs have almost doubled in crown cover since 1957.

	Production (lbs. per acre - green wt.)		
	1956	1957	1958
Shrubs	450	1540	2,180
Forbs	5	100	560
Grasses	5	50	140

	Percent Density (Percent)		
	1956	1957	1958
Shrubs (crown intercept)	5.4	15.1	27.2
Forbs (crown intercept)	--	--	4.6
Grasses (Basal area intercept)	.12	.30	.36

C. P. Pase

Precipitation and streamflow in Arizona chaparral

Continuous streamflow measurements were started at the five new experimental watersheds located in two clusters on the Prescott National Forest in midsummer of 1958. At the same time recording rain gages were installed near the stream gaging stations.

In the Whitespar cluster, where the annual precipitation last year measured about 25 inches, streamflow started with the fall rains and has continued to date. In the Mingus cluster, of estimated lesser precipitation, streamflow has been very intermittent. Except for some runoff coming from snow melt these flows have been of rather short duration.

As might be expected records from the one regular Weather Bureau Station located in the valley bottom between the two clusters of watersheds does not indicate the amount of precipitation for the watersheds. Considerably more study of existing records, and possibly more instrumentation in the mountainous areas of Arizona, will be required before precipitation and runoff can be related throughout the chaparral type.

P. A. Ingebo

SEMIANNUAL REPORT

Division of Watershed Management Research
Southeastern Forest Experiment Station

October 1, 1958 - March 31, 1959

COWEETA HYDROLOGIC LABORATORY

Cooperative Studies

Arrangements are under way for a cooperative, administrative-type study to be made jointly by TVA - Division of Forestry Relations and Hydraulic Data Branch, and Forest Service - Region 8 and SEFES. The study will be to determine the effects of normal, high standard national forest multiple-use management on the hydrology of a 6- to 10-square mile watershed. The main function of SEFES representatives will be to serve as consultants.

Water Yield Studies

The first two years of operation on the conversion of hardwood on south-facing Watershed 1 to white pine indicate that the effect of clearing and burning in preparation for planting did not give the proportionate increase in water yield to that obtained on similar operation on Watersheds 13 and 17. We are still seeking an explanation. The first 9 acres of Watershed 6 has been planted to Alta Fescue. The seedbed was prepared by making several passes with a horse-drawn spring-toothed harrow. About 25 percent of the area was too steep for the horse and was prepared by hand, cutting trenches on the contour similar to roadbank stabilization methods. The soil was highly acid, requiring an average of 3 tons of lime per acre and deficient in nitrogen, requiring a ton of 5-10-10 fertilizer per acre. We are now clearing the next block and expect to plant another 8 acres in July. The balance of the watershed--5 acres--will be cleared and planted this fall if possible, or next spring.

Electronic Computing of Streamflow Data

Our trial run of electronic computation of streamflow data has been completed and the results are encouraging. The trial run was made on one year's record of flow, which had been previously processed with a discharge integrator. The difference between the two methods averaged two percent for monthly values, which is satisfactory for a planimetering operation.

The programming for the electronic computer has been so designed that formula and other data for each weir are entered individually. This will include actual calibration of each weir and its overflow characteristics. Velocity of approach corrections will be made only when value exceeds one percent.

It took a forestry aid one week to tabulate and check 4900 points of stage and time data for one year's record.

The cost for electronic computing of one year's record was $71, of which $33 was for keypunching and verifying, and $38 for time of "650" computer and tabulator. The programming and electronic computing was done by Jerry Klutter at Duke University.

The next step needed is to have the time-stage data recorded for direct use with electronic equipment. The U. S. Geological Survey for the past year has been working with the Fischer and Porter Co. of Hatboro, Pennsylvania, in developing and testing such a recorder--called the "Shaft input digital punch."

This instrument consists of an input shaft coupled by means of a direct gear drive to a 360-degree code disk. A paper tape punch mechanism within the equipment records the digitized shaft input data as measured by the angular position of the code disk. The shaft input is converted to 1 part in 8000 and is recorded, unambiguously, on the paper tape. The paper tape punch mechanism is the only portion of recorder requiring electrical power. An external battery provides this power during the readout interval. A digital readout can be initiated by means of an external contact closure at any desired time interval greater than 10 seconds. Upon initiation by the external contact closure the punch mechanism completes the readout cycle. The readout cycle consists of: locking the code disk and range wheel; properly locating the readout mechanism; and actuating the paper tape punch head. The mechanism and circuit is designed to minimize power drain on the external battery supply.

The readout is in a binary decimal code on punched paper tape and can easily be read by relatively inexperienced personnel.

The tape can be designed to meet the usual head ranges of our weirs. The head can be recorded to the nearest thousandth of a foot.

An electrical clock operating on batteries has been designed by Hamilton Watch Co. to activate the readout.

The U. S. Geological Survey has been testing the operation of this instrument for the past year under laboratory conditions of extreme climatic changes. They expect to start field-testing it in May 1959.

The cost of the instrument is expected to be about $350 under Government Contract, which is about twice that of an FW-1 instrument.

The one remaining step in the operation is to convert the binary code punched tape to IBM cards for use in the "650" computer. The Fischer and Porter Company has developed a translator to accomplish this step. The translator can either be rented or the company can furnish the service if amount of work does not warrant renting or buying the translator.

The advantages of this electronic method of recording and computing of streamflow data are numerous. Chart shrinkage and weekly chart changing would be eliminated. All personnel error would be eliminated in computing, and all computing done to the same accuracy. Runoff computations can be kept as current as desired. The runoff data on IBM cards are available for any statistical analysis desired.

Personnel

Three persons have returned to college for graduate study: John D. Hewlett to Duke in February for his Ph.D with thesis problem on plant physiology under Professor Kramer; Peter E. Black to Colorado State and Pack Foundation in March for his doctorate, thesis not selected; and Alden Hibbert to Utah State in December for his Master's degree, with his thesis on subsurface flow. Lloyd Swift, Jr. returned to Coweeta in October after completing his graduate work at North Carolina State and a tour in Europe, including attendance at an International meeting on Conservation in Greece. He expects to be granted his Master's degree this June with completion of his thesis on the effect of slope and aspect on solar radiation.

Visitors

Visitors totaled 150 during the past six months and included 80 from Federal Agencies, 35 from State Agencies, 17 University graduate students, and 12 from foreign countries.

Meetings

Whelan, Hewlett, and Black attended the SCSA October meeting in Asheville; and Hewlett, the AAAS December meeting in Washington.

Publications in Preparation

Hewlett, J. D. and Douglass, J. E., "The Statistical Limitations of the Gravimetric Soil Moisture Sampling Method."
Meginnis, H. G., "Increasing Water Yields by Cutting Forest Vegetation." To be presented in Germany at the 1959 annual meeting of the International Association of Scientific Hydrology.

A p-19 moisture probe and model 2800 scaler have been purchased for use in soil moisture investigations at this center. Current work will involve technique studies in how to measure moisture by the neutron method.

One of the big problems with this instrument, as well as other measurement techniques, is the limitation in the number of observations which can be obtained in one day. Present studies involve measurement of 46 access tubes to depths of from 8 to 16 feet--a task which involves several days operation. The problem can be partially solved by measuring only part of the depths in one day; such as, measuring only to 4 feet one day, 4 to 8 feet the next day, and 8 to 16 feet on still a different day. This involves a slight error but still allows valid comparisons of equal depths and total depths, since all holes are treated or measured in a similar manner.

Another technique problem, as yet unsolved for piedmont soils, is to determine the uniformity of soil moisture distribution and losses under typical cover types. Once the uniformity test is complete, optimum sample size can be distributed to best advantage between plots and blocks so that future process studies can be established on a sound statistical basis.

A related problem is "How deep into the soil should moisture be studied and from what depths does the vegetation obtain its moisture?" Previous gravimetric and resistance studies have shown that moisture is lost throughout the surface 8 feet of soil and present studies call for measurement of moisture to 16 feet. Possibly this depth is not sufficient, for while inserting access tubes, a 1-1/2 inch root was extracted from the 12 to 13 foot depth and feeder roots were observed at 16 feet.

These deep tubes will also permit study of recharge of soil moisture to much greater depths than was possible previously. Such studies are particularly important in the Piedmont where, during some years, moisture recharge under forest vegetation does not occur below 4 feet.

Another phase of current studies involves soil moisture distribution patterns under thinned stands. Under heavy thinnings, different moisture populations exist at different distances from trees during certain seasons. This adds to the problem of sampling moisture. The present study involves sampling moisture on lines between trees. Average moisture conditions will be determined by weighted stratified samples. It will also permit testing of the theory that the moisture level at a predetermined distance from the tree represents the average moisture conditions under the stand.

SEMI-ANNUAL REPORT
Division of Watershed Management Research
Southern Forest Experiment Station

October 1958 - March 1959

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Results from Active Studies

Overland Flow

At the Oxford, Mississippi, Research Center, nine small experimental watersheds (2.12 to 3.58A.), representing three cover types, furnished information on surface runoff and soil erosion. The cover types were old fields, depleted hardwoods, and 20-year-old loblolly pine plantations. The outstanding difference between types was the small amount of runoff from the pine plantation units. The average surface runoff from these three units for the 12 months period January through December 1958 was only 2.4 percent of the precipitation, as compared with 9.9 percent for the depleted hardwood units and 14.5 percent for the old-field units. Precipitation varied from 52.94 to 56.50 inches in the various installations. Runoff from the individual units was generally proportional to the area of loessial soils. Average sediment yields per unit for the year were 62 lbs. per A. from the loblolly plantations, 627 lbs. per A. from the depleted hardwoods, and 731 lbs. per A. from the old fields.

Measurements of runoff and erosion were started on three small watersheds on upland pine-hardwoods on January 1, 1959. Also, measurements were made on plots on the old-field and depleted hardwood watersheds to establish relationships of soil hydrologic characteristics to surface runoff.

Soil Moisture Storage

At the Oxford Center, significantly more soil moisture was found on plots from which all hardwood overstory was removed as compared to plots from which only the overstory or the understory hardwoods were removed. Soil moisture content was well correlated with survival and growth of planted loblolly pine seedlings.

At the Vicksburg Center, highest correlations of single factors with moisture loss from the surface foot of loess

soil in Mississippi were obtained with soil temperature and evaporation pan data (r = 0.79 each). Solar radiation gave a slightly lower correlation (r = 0.76).

The Vicksburg Center started a preliminary study of soil moisture and soil strength as related to freezing and thawing. The work was undertaken in cooperation with the Lake States and Northeastern Stations.

Watershed Condition Criteria

Hydrologic condition data were taken on every 16th forest survey plot in southwest Arkansas. Preliminary examination of the data suggest the possibility of good correlations between hydrologic class and site productivity and land-use factors. It is planned to continue this work on forest survey diagnostic plots throughout Arkansas and on all survey plots on the Ouachita and Ozark National Forests.

Modified Range Improvements

At the Harrison, Arkansas, Research Center, plots on an area converted from hardwoods to range by aerial spraying yielded runoff 21 of 29 weeks during the latter part of 1958. The role of hardwood forests in maintaining good watershed conditions was brought out in a study of soil physical properties. The soil was a silt loam with considerable organic matter and 63 percent total pore space. Only 15 percent of the soil aggregates were 0.5 mm. or smaller in size, and 41 percent were larger than 2 mm. Hardwood litter averaged 7,500 lbs. per A. four years after a fire.